SEPTEMBER 18, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Filtration of Hydraulic Circuits

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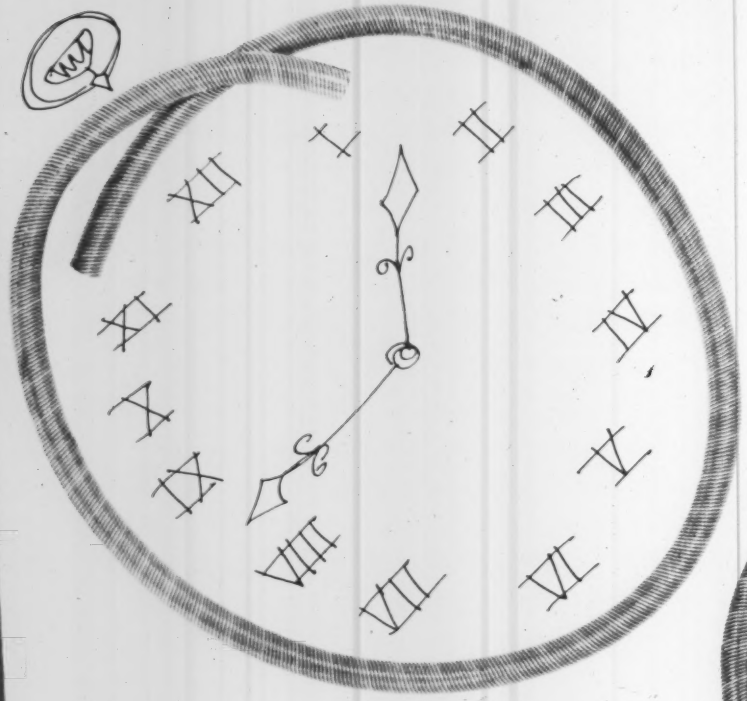

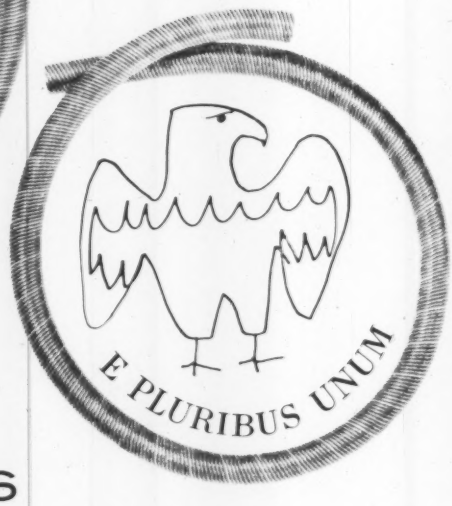

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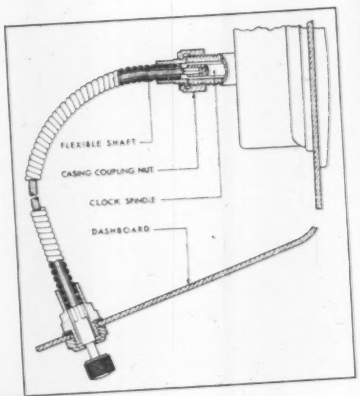

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IN FLEXIBLE SHAFTS

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S.S.White Industrial Division, Dept. 4, 10 East 40th St., New York 16, N. Y. Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

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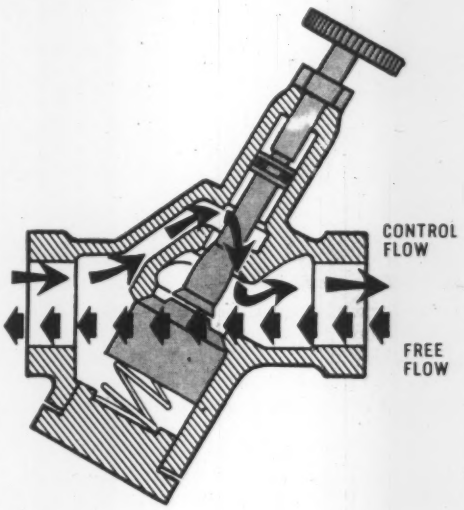
Tranquilize your cylinders

Rx

Ross speed control valves

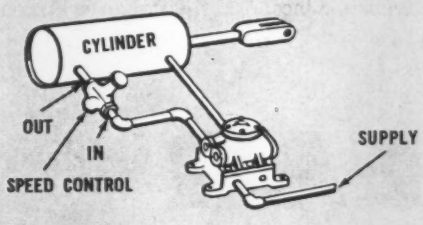


FREE FLOW TO CYLINDER (LEFT)
CONTROLLED FLOW FROM CYLINDER

PRICED WITH THE LOWEST

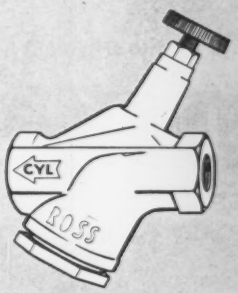
By keeping full power driving the cylinder but metering the flow from it, you can get smooth, positive and infinitely variable control of the cylinder speed without the problems that come with trying to adjust cylinder movement by varying inlet pressure. This is why speed control valves are so satisfactory for making cylinders act right. And why do so many specify Ross speed controls?

Simply this. When you turn the adjustment screw things don't "just happen." Instead, you force the air to flow through a carefully engineered variable orifice, an orifice designed to create fine shadings of control at both high and low flow rates. And, this performance is yours in a valve that is designed and built to thrive under rough conditions and still be around for a long time. This valve's only moving internal part is its poppet. You can lock its adjustment against tampering. It mounts in any position. Its aluminum alloy body gives heavyweight performance with welterweight bulk. Join the thousands who profit by using Ross speed control valves.



The speed control valve as used between a 4 way valve and a cylinder, shown above, regulates (slows down) the piston rod retraction.

FULL RANGE IN STOCK



3 ADJUSTABLE HEAD STYLES AVAILABLE, KNOB, PIN OR SLOT

ALUMINUM ALLOY BODY

BUBBLE TIGHT POPPET

PIPE SIZE ¼, ⅜, ½, ¾, 1, 1¼

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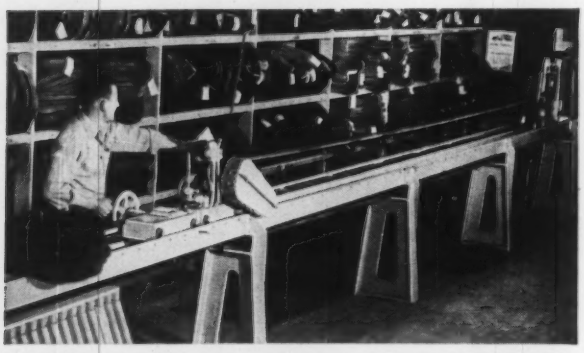
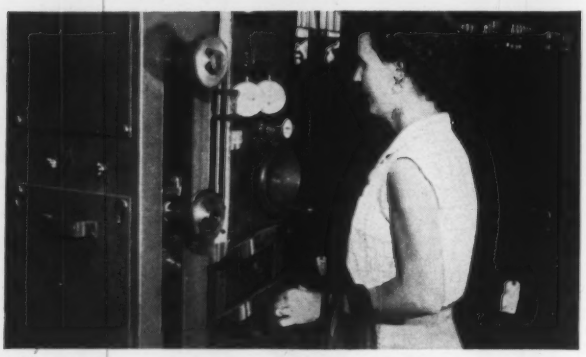
Circle 404 on Page 19

Only V-Belts with the Green Seal give you





Precise measurement of every Goodyear V-Belt and coding to unusually fine tolerances prepare the way for more exact matching of sets—at factory, warehouse, or by distributors. The built-in quality of Dimensional Stability assures that belts stay matched, for life.

dimensional stability – Unsurpassed steel cables or exclusive Triple-Tempered (3-T) Cords provide true dimensional stability from factory to drive.

– that assures you of –

matched sets that stay matched – Sets of belts are matched to the closest standards. And they stay matched under all conditions of storage.

minimum stretch on the drives – Belts on multiple drives work as a team. You eliminate "loafers" – or overworking any of the belts.

– and you also get –

high modulus – You get the greatest possible resistance to shock-loads. You're protected from power loss due to "creep."

friction balance – Covers have the ideal coefficient of friction. No sticking or grabbing in the grooves. And no dusting.

mildew immunity – You're safe from the effects of moisture – in use or in storage. Stand-by belts are always ready for use – no matter how long you keep them.

– and all that pays off in –

–maximum, trouble-free horsepower hours–at minimum cost – on any and every drive in your plant. It's easy to see why you should see your Goodyear Distributor for details. Or write to Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.

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GOODYEAR

60 GOODYEAR ANNIVERSARY

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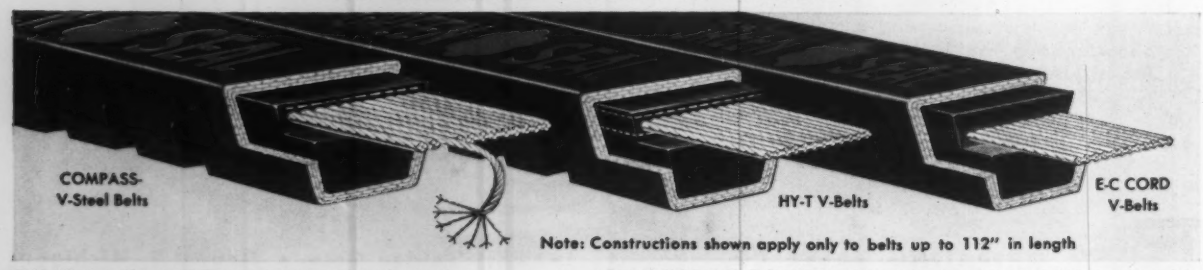

Note: Constructions shown apply only to belts up to 112" in length

Watch "Goodyear Theater" on TV—every other Monday, 9:30 P. M., E. D. T.

Compass, E-C Cord, Hy-T, Green Seal–T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

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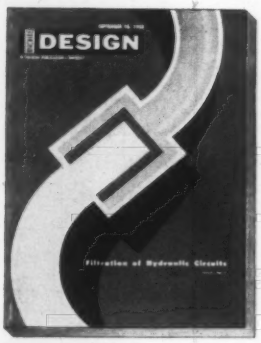

Front Cover: How to keep the solids out of liquids is the pernicious design problem solved by filters. George Farnsworth's cover shows the basic method, covered in detail in Jerry Taborek's new series of articles starting on Page 138.

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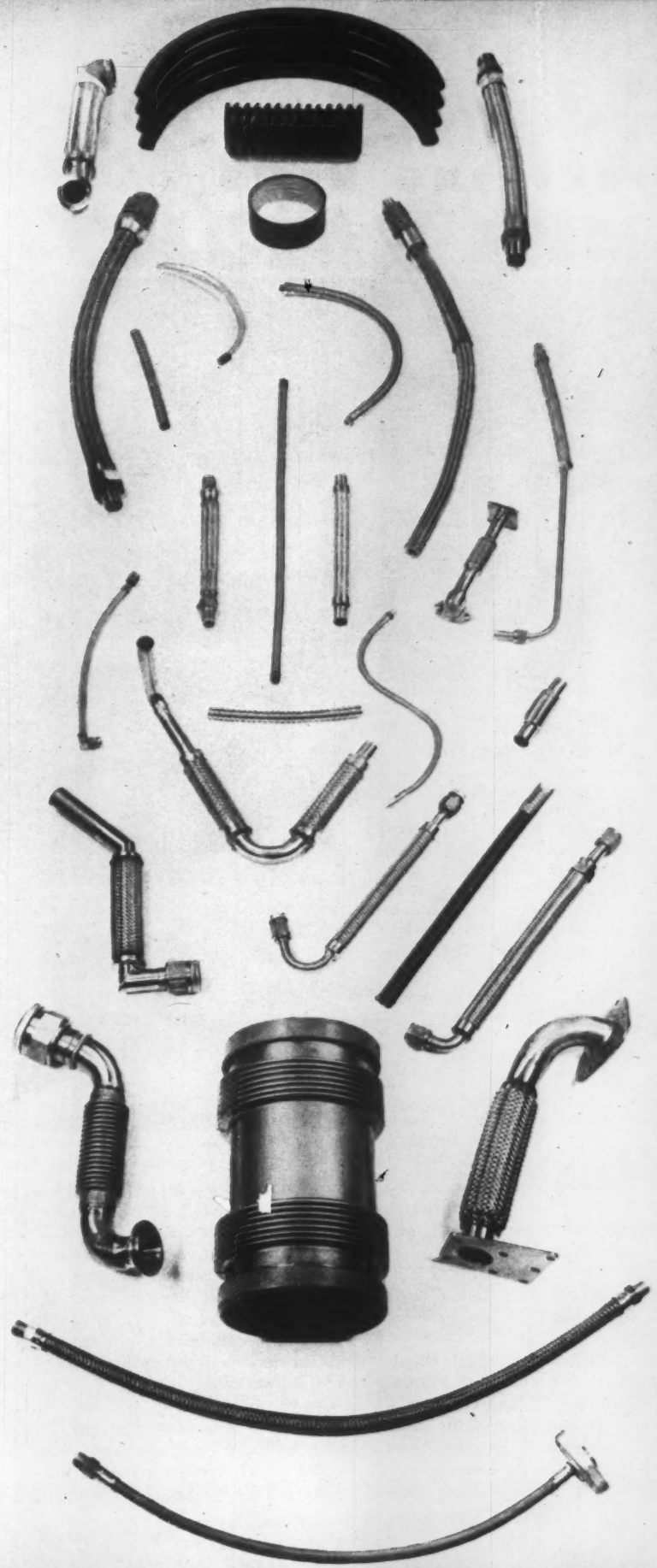

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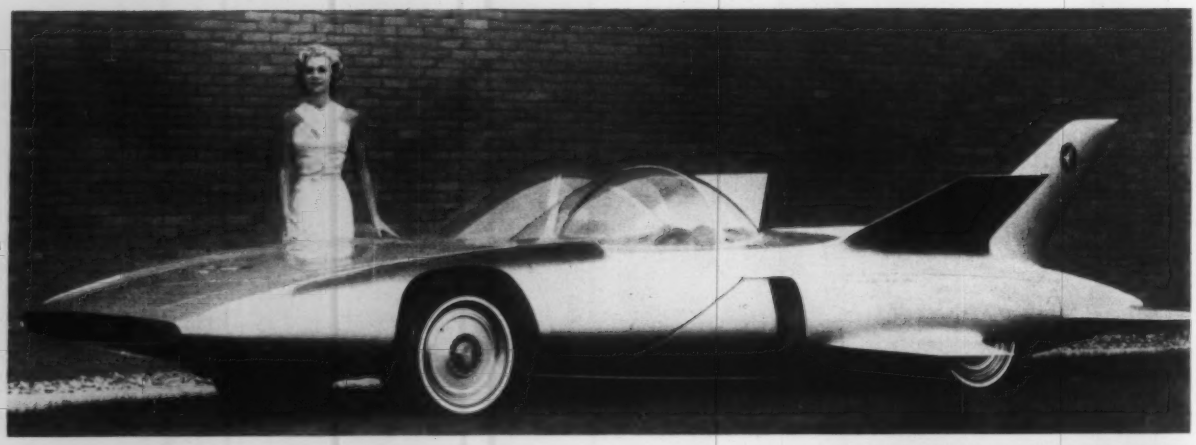
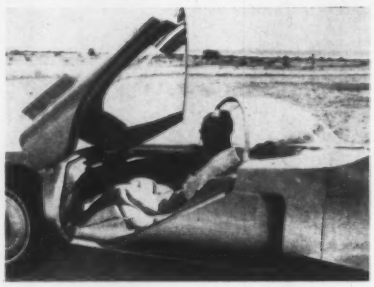


FIREBIRD III, designed around a single-stick control system, is the newest version of General Motors' turbine-powered dream car. Complete with seven fins, the plush, two-place roadster uses a 10-hp conventional engine merely to power its accessories. One of the accessories: A 110-v generator which provides 60-cycle electric power—handy for running household appliances in event of home power failure. Firebird is easy to drive. Pushing the Unicontrol stick forward accelerates the car, pushing it to right or left does the steering, and pulling it back applies brakes. Rotating the Unicontrol handle 20 deg left or right of center puts the car in reverse; an 80-deg rotation puts the transmission in park. When the handle is in normal position the car is in drive. Power-operated gull-wing doors provide easy passenger entry to Firebird. Air intakes for the rear mounted Whirlfire engine are located behind the doors. Drag brakes—large square panels on either side of the vertical stabilizer—open upward into the airstream to assist wheel brakes in high-speed stops. Other specifications:



Main Engine	
Type	Regenerative gas turbine
Power	225 hp
Power turbine speed	27,000 rpm
Gas temp, max	1650 F
Compressor	Single-stage centrifugal
Power turbine	Single-stage axial
Compressor pressure ratio	3.5 to 1
Weight	600 lb
Transmission	Modified Hydra-Matic
Gear ratio	6.9 to 1

Accessory Engine	
Type	Opposed
No. cyls	2
Power	10 hp @ 3600 rpm
Weight	53 lb

Jet Autopilot Works Like Seat-of-the-Pants Flying

Simple System Is Guided By Built-in Model Maneuvers

MINNEAPOLIS—A new aircraft autopilot system, designed for high-speed, high-altitude jets and rocket planes, shares a sort of electronic empathy with the pilot, enabling it to fly the plane the way he wants it flown. The autopilot uses what its designers call logic and built-in learning to determine whether or not the plane is flying as the pilot wants it to; if not, it corrects continually until the desired conditions are achieved. The system's "intelligence" is compared to that of early pilots who flew "by the seat of their pants."

In announcing successful flight-testing of its new autopilot, Minneapolis-Honeywell Regulator Co. says the system thinks its way through maneuvers, rather than feeling its way as do conventional autopilots. The latter do their feeling with the guidance of sensors which measure air speed, altitude, atmospheric pressure, etc. Flight at speeds two to three times the speed of sound, in a rarefied atmosphere, does not permit the taking of all these measurements.

The new adaptive flight control system works without gathering outside information. Rather, it compares the output of gyroscopes and accelerometers with a model of the desired flight performance. The model, which typifies a perfect maneuver under any circumstances,

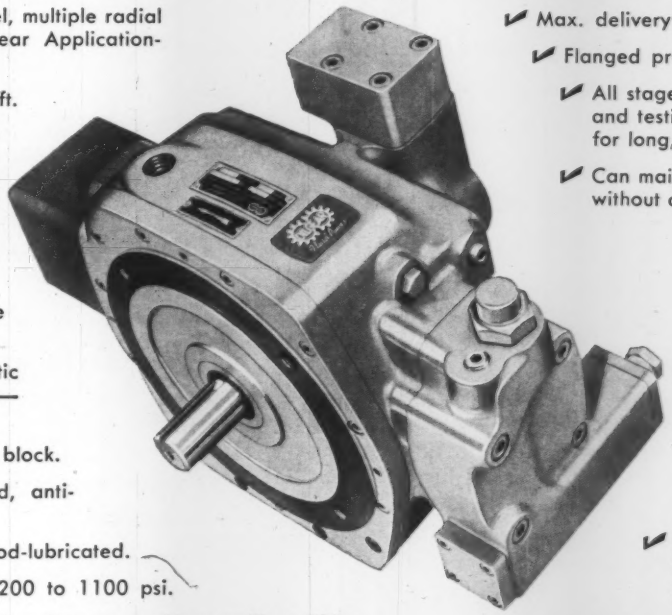
... Fluid Power news

NEW RADIAL PISTON VARIABLE DISPLACEMENT PUMP

OILGEAR ANNOUNCES NEW "Power-Saver" PUMPS

New Type "ANP" Pumps Generate Only Needed Power — Boost System Efficiency

- Simple, one piece, alloy steel, multiple radial rolling pistons — an Oilgear Application-Proved, exclusive design.
- One-piece cylinder and shaft.
- Balanced flat valve (port plate) and separate wear plate to assure a controlled oil film between working surfaces . . . high volumetric efficiency over entire pressure range.
- Integral, adjustable volume control.
- Integral, adjustable, automatic pressure unloading control — 200 to 1100 psi.
- Precision, bearing-type slide block.
- Large, conservatively loaded, anti-friction bearings.
- Completely pressure and flood-lubricated.
- Working pressure range — 200 to 1100 psi.
- Built for continuous, full-load service on pushing, pulling, lifting, lowering applications . . . on machines requiring positive, static loads over intermittent or long periods . . . for automatic charging of accumulator systems . . . for repetitive "ON-OFF" loads up to 1100 psi. New Oilgear type "ANP" pumps will perform more efficiently — with less heat generation — on presses, machine tools, transfer machines, hold-downs, injection molding, die casting — and other machines.



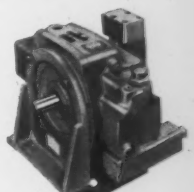
- Max. delivery to 3100 cipm (13½ gpm).
- Flanged pressure and suction ports.
- All stages of manufacturing, assembly and testing under strict quality control for long, dependable service life.
- Can maintain a static load indefinitely without overload or excessive heating.
- Adjust pump volume to suit optimum ram speed — no excess oil to "wire-draw," blow past a relief valve or generate heat.
- Adjust pressure to maximum force needed. When this preset pressure is reached, control automatically reduces pump to slip stroke to save power — reduce heat.
- Available clockwise or counterclockwise rotation at no extra cost.

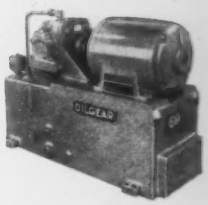
For complete data on these new "Power-Saver"—Oilgear type "ANP" Pumps — call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, requesting your copy of Bulletin 47550 — stating your specific requirements directly to . . .

SELECTION OF MOUNTINGS

Pump case has an accurately finished round face for:

1. Mounting direct to machine. (above)
2. Mounting to a right-angle bracket for "foot-mounting." (right)
3. Mounting to a round adapter for NEMA type "C" electric motor frames.
4. As Standard and "Custom-Built" "Power-Paks"—(right) . . . . complete, compact sources of Fluid Power. Standard "Pak" consists of "ANP" Pump with round adapter or right-angle bracket, coupling, electric motor, 23-gallon differential capacity welded steel base, piping, air breather, filling strainer, fluid level gauges, baffles, clean-out covers, drain plugs, auxiliary pipe connections, and mounting and leveling lugs.





Oilgear's *"Power-Saver"* Pumps and simplified circuitry reduces engineering, production and assembly costs . . . promotes safety, improves performance and system efficiency.

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modifies commands as necessary so that the plane's response is what the pilot would expect.

Honeywell says its new system is less complicated and easier to build than those presently made for supersonic aircraft.

Engineer's Future Is Conference Topic

CLEVELAND—Valuable coverage of mechanisms design—practical and theoretical—is always assured at the Mechanisms Conferences. This year, two experts on the personnel and professional sides of engineering will present some valuable pointers in aiding the engineer to analyze his own progress, or lack of progress. Dr. Richard W. Wallen, prominent psychologist, educator, and management consultant, and James F. Young, manager of General Electric Co.'s General Engineering Laboratory, Schenectady, N. Y., are the qualified experts.

Dr. Wallen will speak at the Conference banquet on Monday evening. His subject deals with an important consideration in any engineer's life: "An Engineer's Future" . . . how personal and environmental factors determine a man's future progress.

Speaker at Tuesday's luncheon is Mr. Young. He will also deal with "An Engineer's Future," in terms of what an engineering manager sees as the opportunities and requirements upon engineers in the expanding future of technology.

A total of 22 events, including the discussions by Wallen and Young, will be presented during the two-day Conference on October 13 and 14. Two experts will journey to the U. S. from overseas to present papers: Dr. Rudolf Beyer, professor of kinematics and mechanism design, Technical University, Munich, Germany, and J. Hirschhorn, school of mechanical engineering, New South Wales University of Technology, Sydney, Australia. The Conference program, with abstracts of all papers, appeared in the Sept. 4 issue of MACHINE DESIGN.

Co-sponsored by Purdue University's School of Mechanical Engineering and MACHINE DESIGN, the Conference will be held on the Purdue campus, West Lafayette, Ind. Registration, room reservation, and program details appear on Page 212 of this issue.

For any additional information, write to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

AN ENGINEER'S FUTURE will be the subject of discussion by two experts in personnel and engineering at the Fifth Mechanisms Conference. Dr. Richard W. Wallen, left, is director, managerial training division, Personnel Research and Development Corp., Cleveland. Mr. James F. Young is manager of General Electric Co.'s General Engineering Laboratory, Schenectady, N. Y. The technical program features 19 papers by mechanisms experts.

Topics

There'll always be an English muffin, and now a device has been invented for breaking the muffin in two for toasting. According to the patent issued on a "tearer-aparter," English muffins, scones, and corn bread should be torn—not cut—to provide a crumbly surface for toasting. This kitchen gadget holds a muffin and runs it through with two sets of tines. Opening it pulls the muffin apart. In addition to the hand-operated, one-muffin version of the tearer-aparter, the inventor has applied for a patent on a mechanical model for use in bakeries and has designed machinery that will dismember 500 dozen muffins an hour.

• • •

Contented milk packager should be one who owns machinery developed by American Can Co. to fill 14,000 quarts an hour. The new Canco automatic dairy packaging line opens, fills, and closes 240 milk cartons each minute—twice as many as the fastest equipment now in use. Filling cartons smaller than quart size, the machine is, of course, even faster.

• • •

Zipper has lost its teeth and had them replaced by thousands of tiny nylon hooks and loops. A new fastener tradenamed Velcro is made of two strips of nylon fabric, one bristling with hooks, the other containing loops. Pressure closes the fastener, and it "peels" open. Inspiration for the zipperless zipper came from a Swiss inventor's encounter with a burr patch. His fastener uses the burr-sticking-to-clothing principle to keep closed.

• • •

Space sweepers — satellites which would clear a path through space rays to permit safe passage of earthlings—were proposed at a recent meeting of the International Astronautical Federation by Dr. S. Fred Singer of the University of Maryland. Another way to escape radiation, he said, is to take off over one of the poles, where there are apparently natural "holes" in the radioactive band.

• • •

Demand for abacus beads, which hasn't been really brisk for quite a while, has picked up with the discovery that they make attractive costume jewelry. In Korea, the abacus industry began to wane at the end of the nineteenth century. However, workmen kept right on turning out beads, pausing only to tool up for production of plastic as well as wooden beads. American ingenuity, applied by industrial designers Smith, Scherr & McDermott, Akron, Ohio, has expanded the operation to include stringing the beads to make necklaces and bracelets for sale in the U. S.

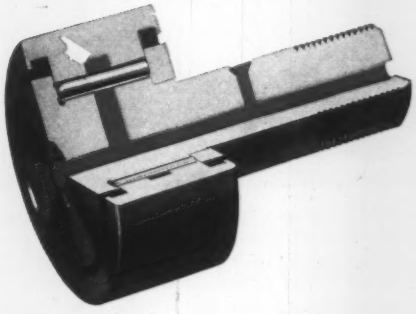
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4" are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

engineered electrical products

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McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 NORTH LAFAYETTE ST., VALPARAISO, INDIANA

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Three-Phase Motor Users Face $20-Million Decision:

Does Third Wire Need Overload Protection?

CLEVELAND — Admitted that overload protection in two wires of a three-phase motor does not protect the motor under all fault conditions, is this reason enough to change the National Electrical Code to require three-line overload protection?

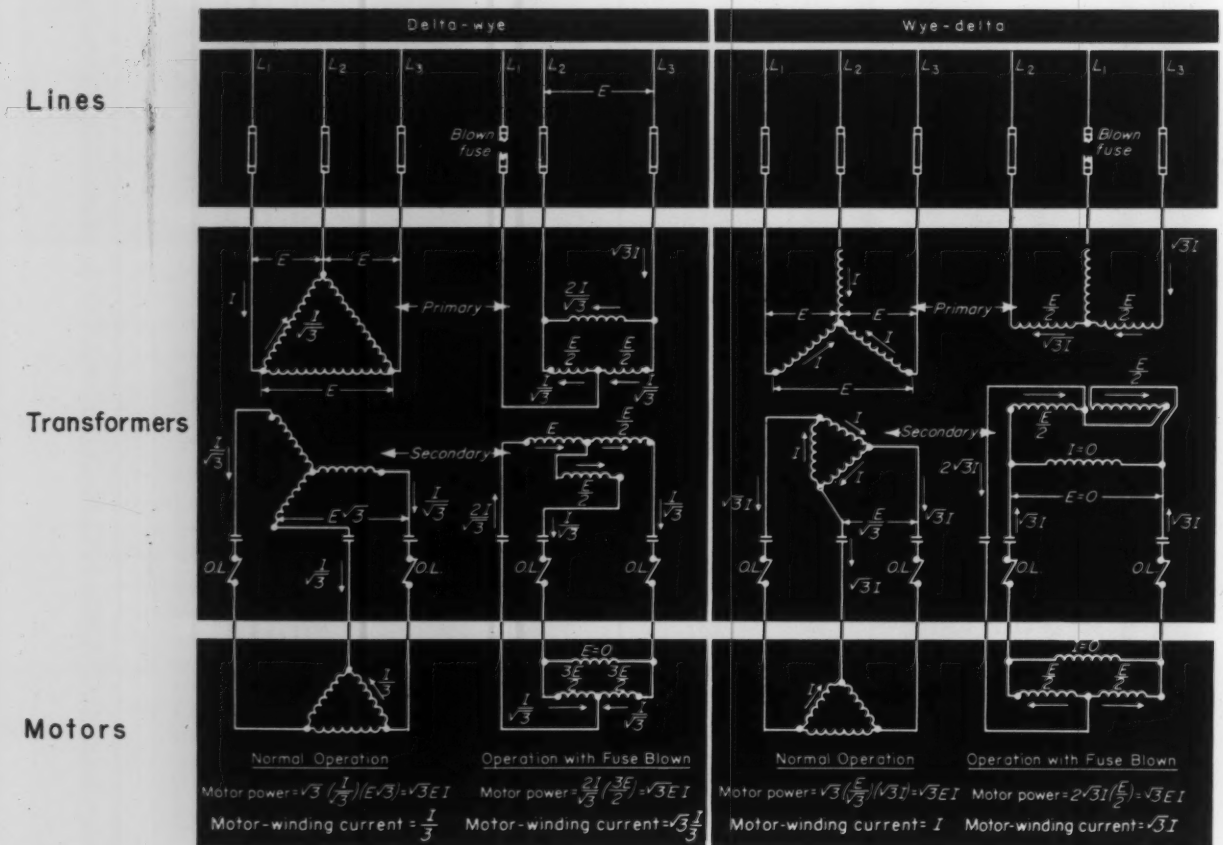
If the answer is "Yes," three overload devices will be mandatory in all three-wire industrial motor applications. Most control equipment now in use will be rendered obsolete, and U. S. industry, according to some manufacturers, will be faced with an additional annual bill of $20 million.

Background to battle is the practice of incorporating overload protection in only two of the three input leads for most three-phase motors used in industry and commerce. Many manufacturers contend that this is adequate. But in certain circumstances, it is easy to show that protection in just two lines does not save the motor from damage. Circuit sketches, below, show two possibilities.

Because the three-phase motor protection problem was clearly recognized many years ago, a clause was inserted in the code to cover situations like unattended irrigation and oil-fired pumping rigs, which are vulnerable to lightning damage. Under this clause, local inspectors could, at their option, insist on the use of three overload devices in three-phase motor controls.

A sampling of opinion in the industry by the editors of MACHINE DESIGN shows that there is no uniform agreement that the NEC should make the third-wire protective device mandatory. Indicative of varying viewpoints was the vote of the NEC code-making panel: 7 members for, 2 against, and 4 abstaining. The panel's recommendation has been accepted by the NEC correlating committee for consideration by all interested parties.

Comments and recommendations can be sent to Mr. W. H. Biester Jr., Chairman, Code-Making Panel No. 11, Electro-Construction Co., P. O. Box 7466, Philadelphia 1, Pa.



When an open occurs in one winding of ungrounded three-phase wye-delta or delta-wye transformers, the motor continues to run and carry its load on single-phase power. If it is assumed that the motor continues to draw the same power, current through each motor winding can increase by as much as 173 per cent. The protection problem arises because one of the secondary leads from the transformer to the motor will carry a much higher current than the other two leads. If the high-current lead is not equipped with an overload, the overcurrent condition in the motor will not trip either of the protective relays in the other two lines.

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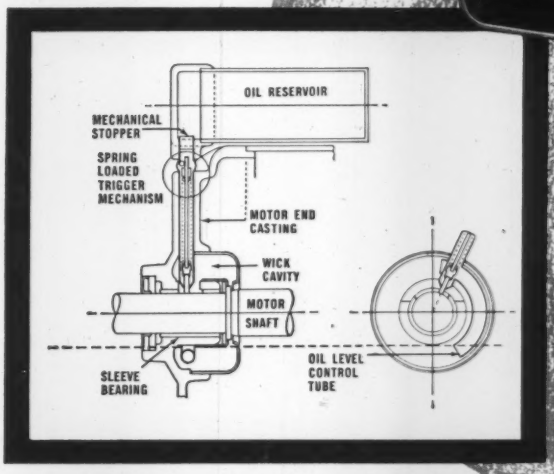

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FACTS about SELF-LUBE MOTORS

FROM THE HOME OF DEPENDABLE "FRANKLINEERED" MOTORS

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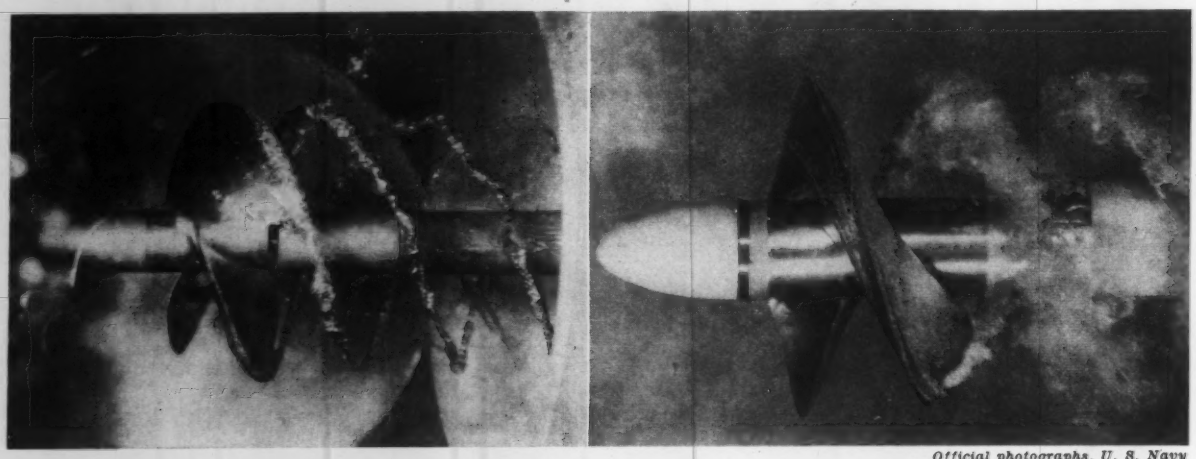
Breakthrough in Propeller Design Promises Faster Ships



Official photographs, U. S. Navy

OLD: A physical barrier to increasing the speed of ships occurs when propellers begin to cavitate at high rotational speeds. (Cavitation: Formation of vapor pockets due to high velocities, low pressures surrounding the fast moving blades.) When the vapor pocket becomes longer than the blade chord, a supercavitating condition exists. At any degree of cavitation, conventional propellers suffer a general breakdown in performance. Effects are a loss of thrust and efficiency. In addition, mechanical impact of collapsing vapor bubbles causes severe erosion on blade surfaces.

NEW: The supercavitating propeller, announced recently by Office of Naval Research, operates best at high, supercavitating speeds. It exploits supercavitation by utilizing a blade section that permits free flow of cavitation bubbles from the trailing edge. A bonus feature is the elimination of blade erosion. The propeller is expected to be an ideal match for high-rpm gas-turbine engines, and promises an immense increase in the speed of ships. The principles involved may eventually be applied to the design of pumps for closed-circuit hydraulic systems.

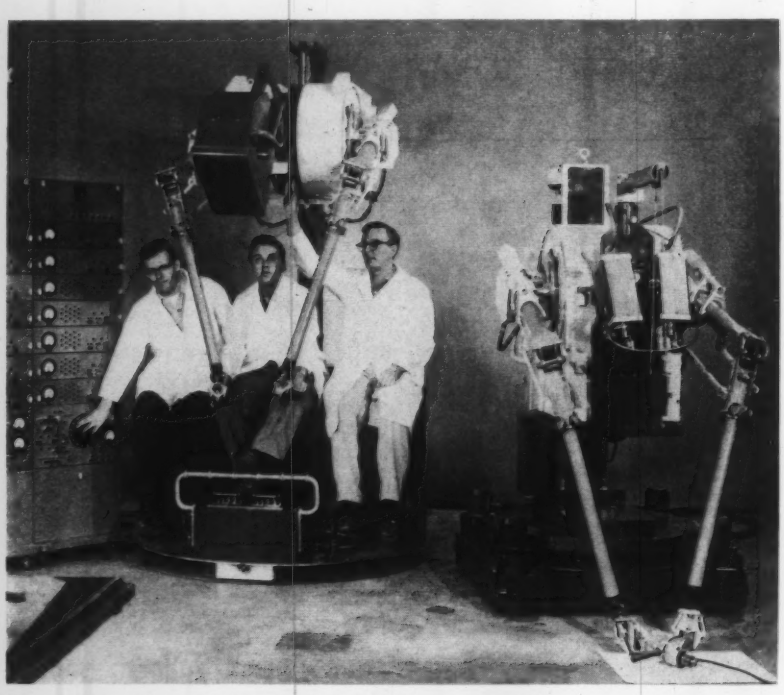
New Slave-Robot Helps Improve Breed

CHICAGO—A "slave-robot," weighing more than a ton and standing 8½ ft tall, is capable of making complete experiments and repairs in an atomic "hot cell." With at least one arm and hand intact, it can even repair itself.

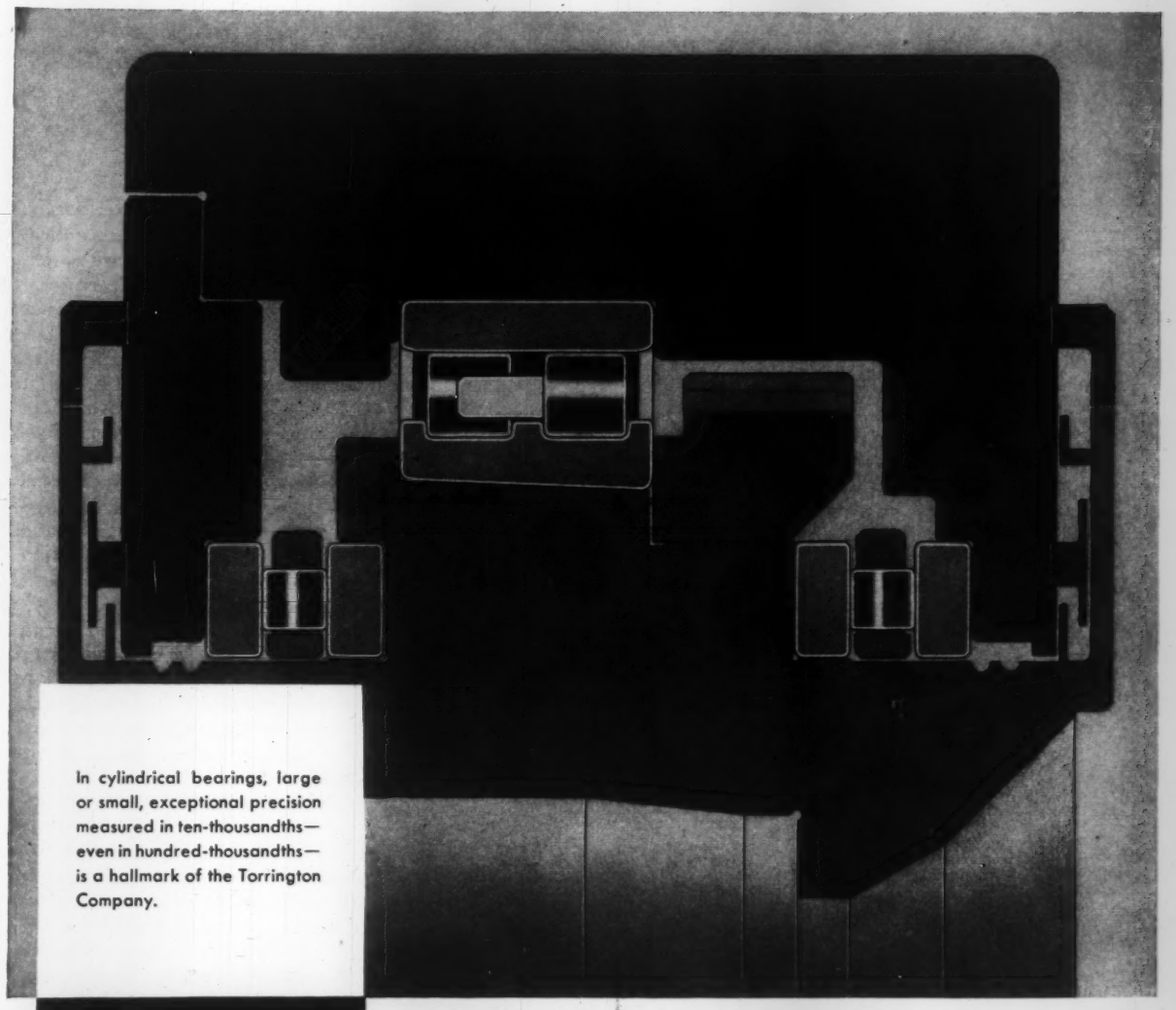
The metal man has a very low IQ but a strong back: He can carry 30 lb continuously and 50 lb intermittently with each of his two arms, according to Raymond C. Goertz, director of Argonne National Laboratory's Remote Control Engineering Div. Third in a series of similar devices, the robot is operated by a man sitting at a set of master controls.

By pushing a series of foot switches, the operator moves the robot into position, and then, with the electronically controlled master-slave manipulator, directs arm and hand motions.

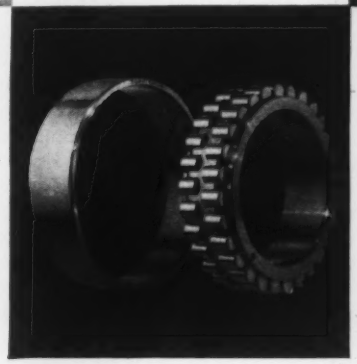
The slave-robot has electronically controlled "arms," a cable crane, and stereo television, all



Slave-robot (right) is designed for repair and handling operations involving radioactive materials behind heavy shielding. At left are man-operated control units. The robot has electronically controlled "arms," a cable crane, and stereo TV for auxiliary "seeing."



In cylindrical bearings, large or small, exceptional precision measured in ten-thousandths—even in hundred-thousandths—is a hallmark of the Torrington Company.



Turns true within three "tenths"!

To the engineer, that means these large Torrington Cylindrical Roller Bearings have a total radial runout of only .0003″—three ten-thousandths of an inch! To anyone, that means ultra-precision.

These are spindle bearings custom-built for Gisholt Machine Company's center drive lathe. The tapered bore, two-row radial roller bearing is 44.2500″ OD, capacity 189,000 pounds at 100 rpm. Face runout is held to .0005″. Each of two cylindrical thrust bearings used is 38.4700″ OD, capacity 105,000 pounds at 100 rpm. Diameter of rollers in any one bearing is held within one-half "tenth"—.00005″.

This close approach to perfection is made possible by specialized equipment and superior workmanship, which go into the manufacture of every Torrington Bearing, large or small. Of course, not every application requires such ultra-precision. But each bearing requirement is given the extra measure of care that makes Torrington quality a byword in industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

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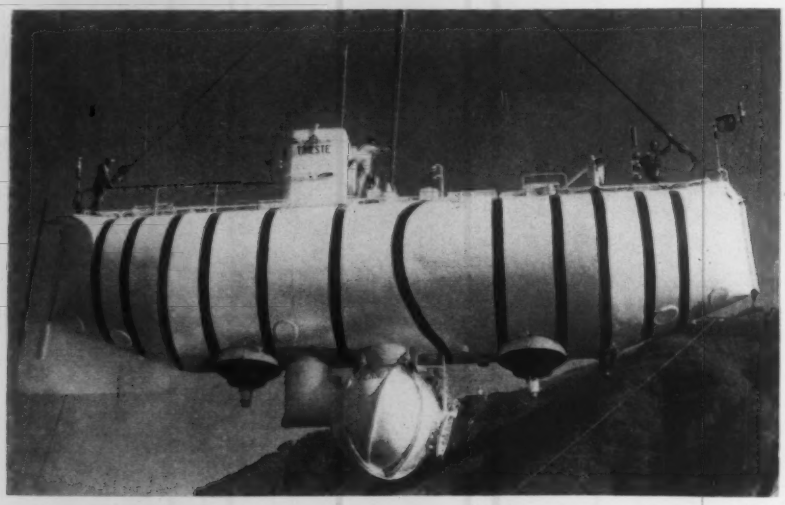
turret mounted on a vertical column rising from a wheeled platform. Arms of the robot can reach down to the floor and up to about 6 ft by moving the arm assemblies up and down on the vertical column.

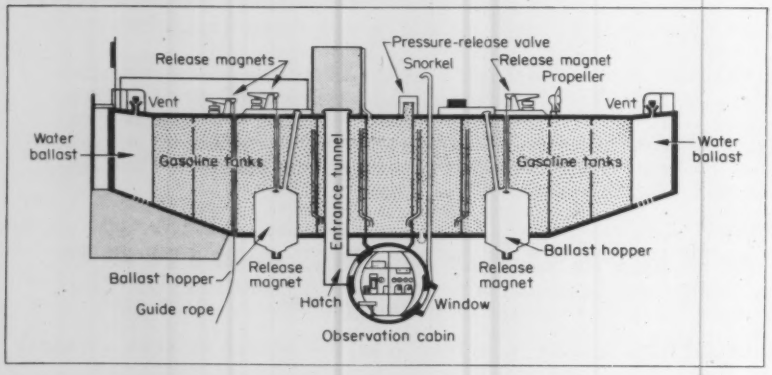
Most important parts of the robot are the manipulators, or mechanical hands with "feel." Explaining the mechanical hands' ability to feel, Goertz says, "The manipulators produce the basic motion of the human hands and reflect back to the operator the forces that are exerted at the slave, thereby giving him a sense of feel. This enables a scientist to handle many complex experimental operations inside a hot laboratory almost as well as with his own hands, without exposing himself to the dangers of radiation."

Goertz stresses that this model slave-robot is not intended for use in a hot laboratory, but to aid in the development of new slave-robots with improved performance.

Gasoline-Filled Blimp Sails Deep Under the Sea



SIMPLE IN CONCEPT, the Navy's recently acquired bathyscaph permits safe exploration of the sea at 20,000-ft depths, more than five times the capability of previous undersea rigs. The unique vessel works like a blimp in reverse. Buoyancy is provided by 28,000 gal of aviation gasoline contained in a thin-walled metal "bag." As the ship descends, water is taken into the bag, compressing the gasoline and reducing buoyancy. Since internal pressure offsets external pressure, wall thickness of the bag is only 1/3 in. Batteries supply power for propulsion and for the fail-safe buoyancy controls. In event of power failure, electromagnets would automatically release all ballast—10 tons of iron pellets—and the ship would bob to the surface. Problem of insulating externally-mounted electrical apparatus against sea water was solved by immersing it in nonconducting liquids with which water does not mix.



Heat to Electricity: Low-Power Source Ready Now

New Material Discovered By Westinghouse Engineers

PITTSBURGH—An "essentially unexplored" class of materials which can convert high-temperature heat directly into electricity, with reasonable efficiency, has been discovered by scientists at Westinghouse Research Laboratories. The materials are ceramics; temperatures required are 2000 to 3000 F.

Although thermoelectric efficiency is low in comparison to conventional power-generating equipment, Westinghouse says the new materials are now suited for specialized applications where lightweight and simplicity are more important than efficiency, and where small quantities of electric power are needed.

First produced in powdered form, then pressed into small pellets for ease of application, the materials consist of mixed-valence compounds of the transition metals. The transition metals are a group lying near the center of the natural table of elements, and include iron, nickel, and manganese. In contrast to solid-state materials generally proposed for thermoelectric power generation, the new compounds are inexpensive, readily available, and easy to work with. Being ceramics, they are inherently stable and chemically inactive at high temperatures.

For many years the thermoelectric effect has been observed in metals, most of which easily withstand the required temperatures. But because metals are good conductors of heat and electricity, their maximum thermoelectric efficiency is of the order of 1 per cent—far too low for power purposes.

More recently, the thermoelectric effect has been found in semiconductors—the class of materials widely used in making transistors and other solid-state devices. Certain semiconductors exhibit quite reasonable thermoelectric efficiencies, but not at the elevated temperatures at which power is most usually generated.

According to Westinghouse, the new thermoelectric materials are probably the first to be discovered in the general category of insulators or nonconductors.

Liability for Atomic Disasters Responsibility of Government

Jurist Points Out Industry's Need for Legal Protection

GENEVA, SWITZERLAND — Government should assume liability for atomic reactor damages "resulting from major catastrophes caused by acts of God—earthquakes, war, sabotage, or airplane crashes, for example," a prominent jurist said recently. Dean E. Blythe Stason of the University of Michigan Law School declared that unless this is done, owners of atomic reactors probably will not be able to insure themselves fully and the economic basis of atomic enterprise could become questionable.

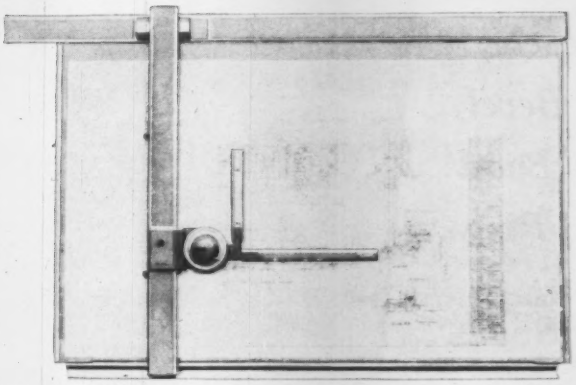
Speaking before the Second International Conference on Peaceful Uses of Atomic Energy, he pointed to a worldwide tendency to adopt the principle of absolute liability in the atomic energy field. This means, he said, that individuals or companies may be held liable for damages, even though accidents occur through no fault of their own.

Stason suggested that individual countries might well establish reasonable limits upon absolute liability in the atomic field to avoid undue burdens upon the new and useful industry.

In general, he noted, "The law seeks what has aptly been called 'the golden mean' between the ancient Roman principle that persons are responsible only for their own faults and the primeval principle that the owner is to be held unconditionally liable in all circumstances."

New headlamps for old cars have a built-in spotlight which throws the lower beam farther down the right side of the road than existing headlamps in pre-1958 cars. General Electric's new Suburban headlamp compensates for decrease in a driver's vision caused by lights of an oncoming car; it is designed to provide more eye comfort and safer seeing than conventional-style lamps, even if the lights of an approaching car are aimed too high or if they are not dimmed. The Suburban is made specifically for automobiles with two headlights and either 6 or 12-v systems.

DRAFTING TRENDS



The Universal Tracmaster drafting machine, currently being introduced by POST, is perfectly balanced for all board angles without protruding counterweights. The Tracmaster features extreme parallel accuracy, offering featherlight responses for easy operation, with the same overarm protractor head used on the famed Universal Boardmaster drafting machine.

Advance information about outstanding new track drafting machine

Over recent years, drafting techniques have progressed to machines and boards designed for variable angle drawing . . . from near-horizontal to high angle vertical positions. There has been a growing need for more efficient tables to minimize draftsmen's fatigue . . . for drafting equipment suitable for long traversing and large layout drawings . . . as well as for drafting machines suitable for ultra-precise detail work.

Now POST brings you the most advanced track drafting machine yet developed. It's the Universal Tracmaster . . . a perfectly balanced X-Y track drafter with unvarying parallel accuracy from one end of the board to the other. The Tracmaster glides smoothly and easily, horizontally and vertically, with precise accuracy of angle and dimension at *any* board angle. All of this is accomplished without use of counterweight attachments of any kind.

An outstanding *exclusive* feature of the Tracmaster is the inclusion of track graduation, *in addition* to all the usual angular and dimensional measurements. On each track, numbered graduations are provided at precise 10-inch intervals —for quick, easy reckoning. In effect, these graduations divide the entire drawing area into a 10-inch grid pattern—useful for establishing reference points or measuring and drawing long lines—with no cumulative error due to repeated scale extensions.

The extremely rigid horizontal beam rail you see across the top of the Tracmaster is mounted to the board by two brackets. Once mounted, there is *never* a need for adjustment. The machined beams *always* stay straight.

Efficient design conserves space

If space is a problem, you'll find the Tracmaster a perfect answer. There are *no* protruding arms or weights in the back, so the machine can be used close to walls or near other tables. You can actually put more tables in a given area using the Tracmaster on a Hamilton Auto Shift or L-Angle Table than you can with any other drafting combination. In fact, in all POST's years of experience in working to serve draftsmen, engineers and designers, this combination of the Universal Tracmaster with modern Hamilton equipment offers by far the best opportunity to materially improve drafting efficiency.

The Tracmaster's protractor head is the same as the protractor used on the famous Universal Boardmaster drafting machine. It provides full 360° visibility; has a powerful, positive and full circle baseline setting; and a ball bearing indexing head. With this protractor head you quickly, conveniently and accurately lock your scales to any position.

For more information on the Tracmaster drafting machine, write today to Frederick Post Company, 3652 N. Avondale Avenue, Chicago 18, Illinois.

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Reader Information Service

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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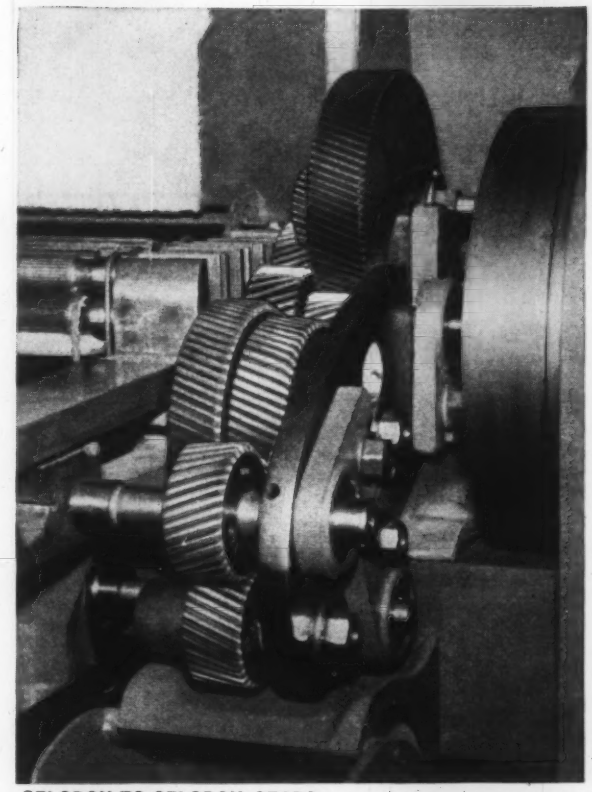
Put strength, long life, silence into gears and couplings with CDF Celoron® molded plastics



CELORON-TO-CELORON GEARS in drawing rolls made by Ideal Industries, Inc., Bessemer City, N. C. These are helical-cut gears—the toughest to machine, requiring the toughest material. Celoron is it. Other Celoron parts for this application are shown below, top right.

WORK MIRACLES IN MACHINERY with this amazing golden phenolic material! Celoron gears help eliminate noise and reduce wear on mating metal gears. Even the roughest-used helicals last . . . and last . . . and last.

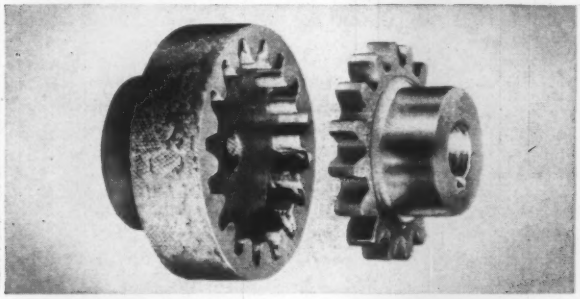
HIGH MECHANICAL STRENGTH. Typical Celoron strengths: tensile, 6,500 psi; flexural, 10,000 psi; compressive, 25,000 psi; shear, 8,500 psi. Dimensionally stable and readily machined, Celoron fills the bill where costly metal parts fail.

ELECTRICAL INSULATION VALUE. Celoron is a non-conductor with high electrical insulation value. It makes ideal mechanical-electrical parts. Celoron couplings effectively insulate motors from driven machinery.

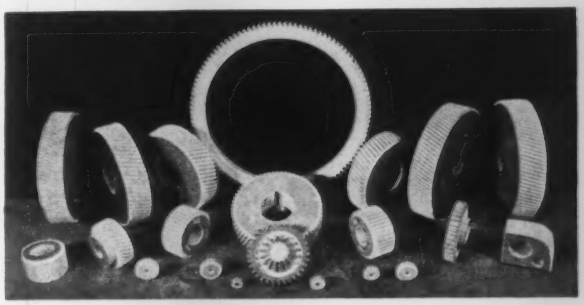
CDF FABRICATION SERVICE. Let the plastics-fabrication and molding experience of CDF save you time and money, and assure you delivery of production quantities of CDF plastics and molded parts—on time and as specified. The CDF man can help you from the very beginning. See his phone number in the Product Design File (Sweet's). Or send us your print or your problem, and we'll return samples and technical literature for your evaluation.

CONTINENTAL-DIAMOND FIBRE

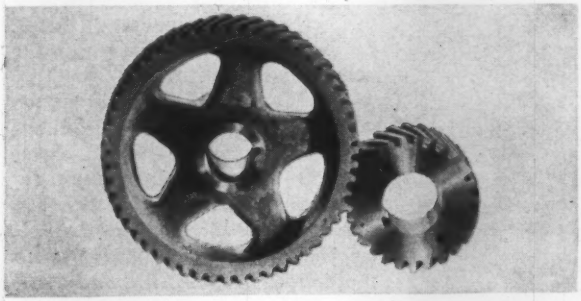
A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 23, DEL.



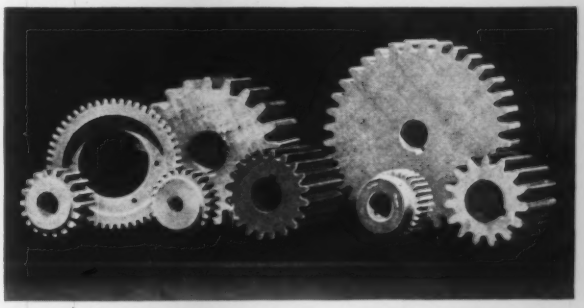
LOW-COST, EASILY-ASSEMBLED CDF Celoron flexible coupling transmits power smoothly, silently . . . insulates motor from machine . . . needs no lubrication . . . works vertically or horizontally.



PRECISELY MACHINED KEYWAYS help keep these Celoron parts silent and strong in the Ideal drawing rolls illustrated in top photograph. Note wide range of sizes and shapes.

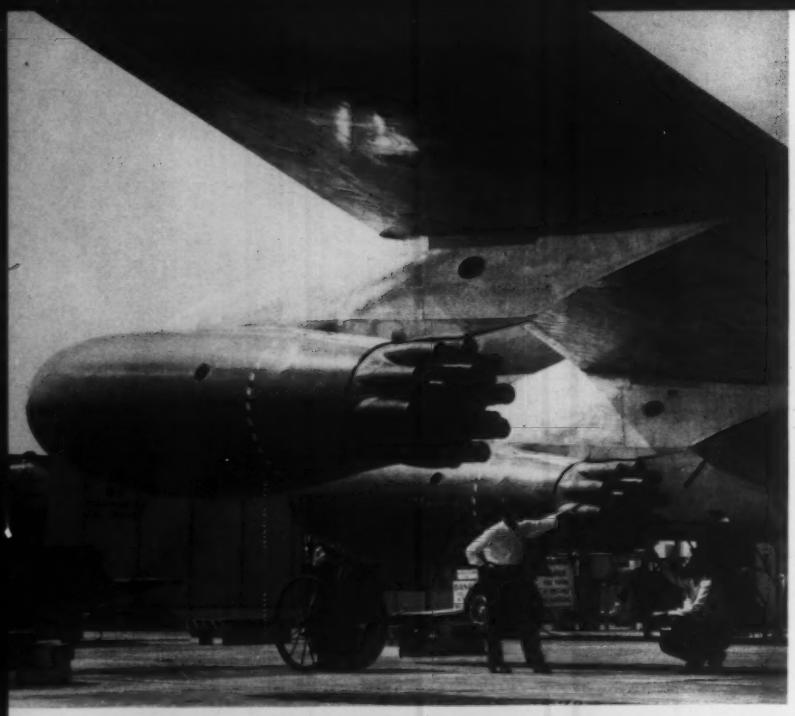


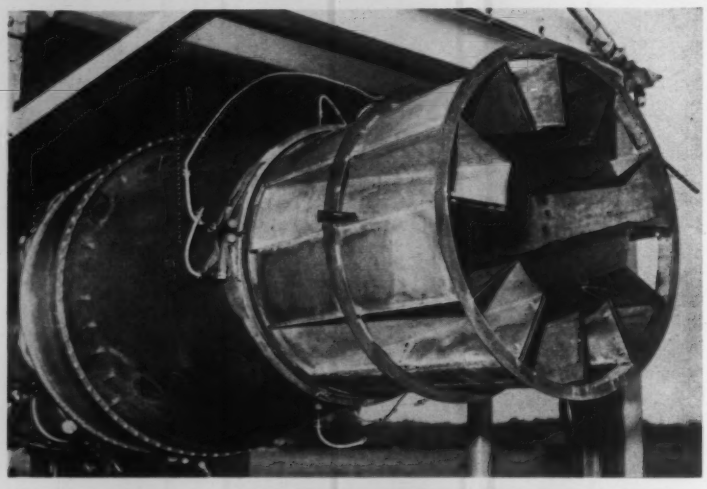
CELORON-TO-STEEL combination makes this long-wearing timing mechanism for gasoline engines. Celoron gear absorbs shock, cuts sound to a minimum, holds timing longer.



STRONG, SILENT CELORON makes both drive and driven gears. In fact, many machine applications are 100% Celoron geared for light weight, elimination of excess play, long life.

Circle 412 on Page 19





(Top) Multitube "organ pipe" nozzle mounted on Boeing 707 jet airliner breaks up the jet so that the stream mixes with the surrounding air. *(Middle)* Corrugated nozzle mounted on a thrust stand is not a flight model, but serves to check the noise and thrust characteristics of the design under test. *(Bottom)* Corrugated nozzle with an ejector is designed to pump secondary air into the jet.

JET

thunder in the suburbs

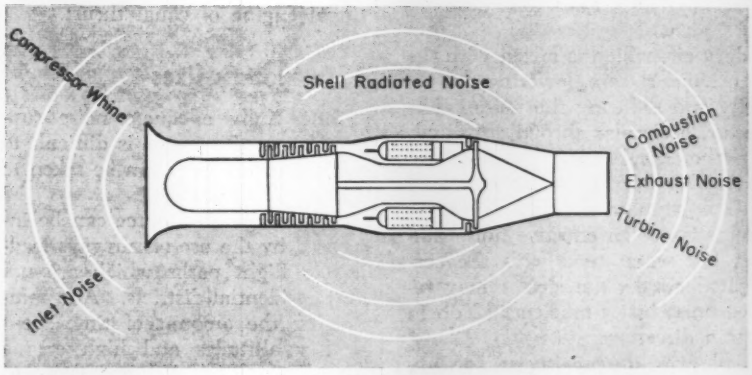
By HAROLD R. MULL
Aeronautical Research Scientist
Lewis Flight Propulsion Laboratory,
NACA
Cleveland, Ohio

JET AIRLINER service, scheduled for inauguration on Nov. 1, threatens to aggravate the already serious noise problem that has plagued airport operators in recent years. Although there are signs of wishful thinking in the industry, there's no ducking the fact that jets make noisy neighbors.

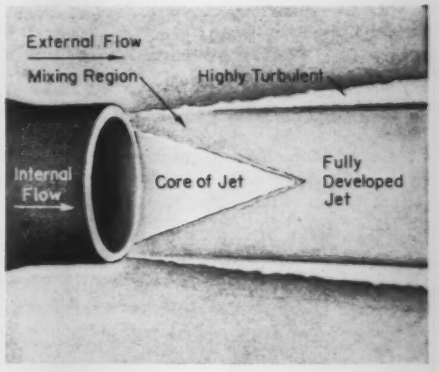
At a distance of 200 ft from the takeoff point, sound level from the jet transport could be 16 db higher than the 119 db from a piston-engine liner like the DC-6. Although this is only a 13 per cent difference on the decibel scale, it represents multiplication of *noise power* level by a factor of more than 6.

Future of the jet air transport could very well depend on a suc-

NOISE...



Of three principal sources of jet-engine noise, the jet itself is by far the worst offender. Attempts to reduce noise level have focused on suppressing externally generated exhaust noise.



Cross-section of idealized jet shows region in which highly turbulent mixing of air and exhaust gases generates intense noise.

cessful solution to the noise problem. Although the 4-engine conventional transport operates with something more than a soothing murmur, it's being used as a criterion for quieting down the jet liner. Attempts to quiet the big jets include study of the sources of jet noise, design and installation of special suppressors, and research on low-velocity jet engines.

Noise makes problems

High noise levels from the jet engines of a giant transport threaten to create serious problems:

- Noise nuisance to communities in the vicinity of airports.
- Passenger discomfort during taxiing, at takeoff, and in flight.
- Impairment of hearing and breakdown of communications among ground-crew personnel.
- Sound-created stresses on the airframe, adding design requirements to prevent structural fatigue.

Most pressing for solution is the nuisance to communities in the vicinity of airports. Because noise from the present piston-engine has been the target of many lawsuits by communities under the flight path, the jet liner must be no louder.

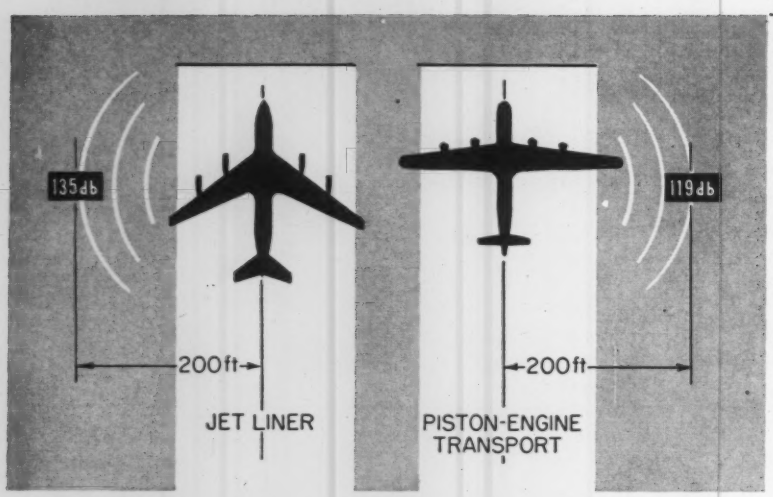
Thus the powerful Port of New York Authority, before granting airlines approval to land ships at airports under their control, insists adequate noise control be proved during normal airplane operation.

Sources of jet noise

A jet engine creates noise by three principal mechanisms:

- Rotating blades of the compressor and turbine produce a characteristic whine, somewhat like that of a siren.
- Irregular and turbulent combustion within the engine may cause "screeching" and "screaming" noises, due to resonances within the burners.
- The high-velocity jet exhausting from the nozzle generates noise as it mixes with the surrounding air.

Noise created by the high-velocity



Maximum noise power levels for 4-engine transports, measured 200 ft from takeoff, show sound energy generated by a jet liner can be six times that from conventional, reciprocating-engine airliner.

jet is the most significant by far. Not only is it the loudest, but it is created outside the engine. The jet exhaust tears out of the nozzle at a speed of close to 2000 fps. Jet and air do not mix smoothly; they roll up into irregular swirls and eddies. The fluctuating eddies—turbulence—cause fluctuating pressures which are radiated as sound waves.

Strength and size of these eddies must be reduced in order to solve the noise problem.

Mixing nozzles

The discovery that turbulent mixing was the major source of jet noise led to hope that nozzles could be designed to control the mixing process. Of the many nozzle shapes tried, most were discarded, but some showed promise:

- The "organ pipe" is now flying on the Boeing 707. The regular circular nozzle is divided up into many small nozzles of different lengths.
- Corrugated nozzles that have deep indentations about the periphery draw secondary air into the jet, slowing down the jet gases.
- Corrugated nozzles equipped with ejectors pump in a greater amount of secondary air.

All of these nozzles have been designed to spread the jet and promote down-stream mixing. Corrugations and interstices admit secondary air, which is mixed with the jet exhaust stream, lowering the velocity and reducing the noise. The ejector, a circular shroud surrounding the nozzle, also pumps secondary air into the jet. When used with a circular nozzle, the simple ejector is not an effective noise limiter, but when used with the corrugated nozzle, the ejector may reduce noise by as much as 12 db in certain directions.

Although the mixing nozzle approach is a promising one, it does not as yet yield all the sound reduction desired. Also, it imposes penalties on aircraft performance, such as increased drag, increased weight, and thrust loss. The penalties cannot be completely eliminated but, with careful design, can be minimized.

Low-velocity engines

Another approach is to reduce the velocity of the jet exhaust stream. Research has shown that a small reduction in the jet velocity will cause a great reduction in the jet noise. Today's engines, designed to operate at high velocities, do not operate efficiently if the velocity is reduced. It is possible, however, to design new low-velocity engines which are both efficient and relatively quiet.

One proposed design operates at a reduced turbine-inlet temperature of 1200 F, as compared with the more conventional 1600 F. The lower temperature results in lowered jet velocity, 1550 fps as compared with 2150 fps. Noise reduction is 9 db. Other important advantages of the low-temperature engine are improved life and reliability. Although design and development would be long and costly, such a low-temperature engine can be made with over-all performance nearly equal to that of existing engines.

The bypass engine is another type that operates at a lower jet velocity. Here, a portion of the inlet air bypasses the turbine, but is mixed with the turbine exhaust, after which the combination enters the nozzle. This reduces the velocity and results in a noise level of about 8 db less than a conventional engine of equal thrust.

Temporary fixes

Since fully adequate noise suppression at the source is difficult to achieve, other steps can be taken to reduce complaints.

Distance to the source can be increased by the use of runways leading to flight paths which are not over residential districts. Also minimizing the amount of time spent at low altitudes and high engine power can result in much less annoyance to residents near airports. Still, use of "preferential runways" doesn't always allay complaints about jet noise. In recent tests at Idlewild, the British Comet IV was called noisy by residents who reported that it passed over at an altitude which appeared higher than that of regular traffic.

When the aircraft is on the flight line, its exhaust can be funneled into large mufflers during engine run-up and testing. Ground crews, who must work near engines when in operation, can be equipped with protective helmets.

To avoid high noise levels inside airline terminals, buildings can be situated at some distance from takeoff points and can be soundproofed as well. Passengers can be carried to the takeoff point by buses.

As the situation stands today, there is no simple solution to the noise problems of the jet airliner. Research is continuing on a large scale, but the time is growing short.

New program timer features complete adjustability

In many applications, a timer has a "standard" job to do throughout its expected life, never requiring a change of timing sequence. But in many others, it's desirable to be able to change the timing sequence and the intervals making up the sequence in a complete cycle.

The new Cramer Type 511 and Type 521 Cycling Timers fill the bill for a unit combining high accuracy with complete field adjustability of as many as eight individual timed intervals. Although these timers can be supplied with preset cams to fit the needs of a present application, the added feature of adjustability makes them the ideal choice where the timing sequence may later be changed.

Operation

Applying power through an external sustained contact starts the timer, which continues to cycle until the control contact is broken. Full cycle time is the total time range of the timer specified, and may be selected from a large number of available ranges. If desired, the timer can be wired to perform one cycle and stop.

At the start of each cycle, the snap-acting SPDT load switches are in the initial positions specified (or established through adjustment) by the user. As the cycle progresses, each load switch is transferred by its operating cam to open or close its connected circuit at the required time and for the required duration.

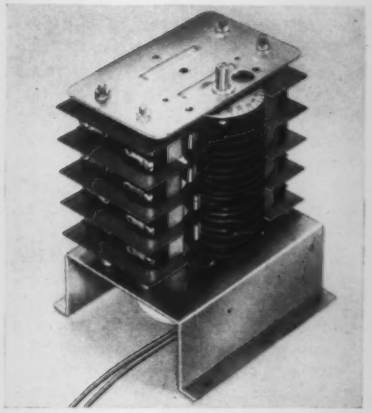
Timing Cam Adjustment

Each SPDT switch is operated by a double cam, one section to close the switch to one contact, the other to close it to the opposite contact. Depending on circuit wiring, either of these actions can "make" or "break" the load circuit. Each section of each cam is independently adjustable through a full 180°, without disturbing any other cam setting, by means of a small spanner wrench furnished with the unit. Adjustment is indicated on a dial which is marked in percent of total cycle time, permitting accurate selection of the desired "make" and "break" points for each load switch.

Features

TIME RANGES — From 1 cycle in 6 seconds to 1 cycle in 48 hours.

LOAD CIRCUITS — From 1 to 3 (Type 511) or from 4 to 8 (Type 521), each controlled by a totally-enclosed quick-make quick-break SPDT switch–rated for 20 amperes at 125 or 250 volts AC (non-inductive).



Field-Adjustable Program Timer Type 521

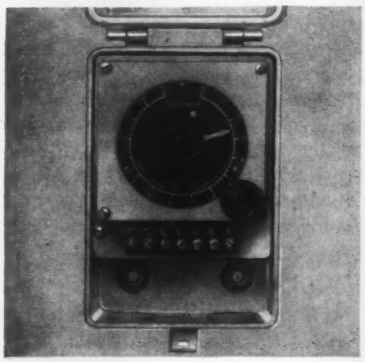
OPERATING TIME — Minimum operating time for each circuit is approximately 1/30 of total cycle time.

ACCURACY — At operating point of any one circuit, 1½°; between any two circuits, 3°.

MOTOR — Cramer high-torque synchronous, for 115 and 230 volts, 25, 50 and 60 cycles. Motors for operation on DC or at other frequencies are available in limited time ranges.

For detailed information and complete specifications, write Cramer Controls Corporation, Box 6, Centerbrook, Conn.

THREE MORE WAYS TO SOLVE YOUR TIMING PROBLEMS

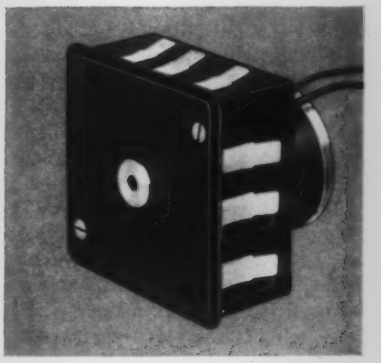


VARIABLE-CYCLE PULSE TIMER TYPE 650

Makes or breaks an electrical circuit for a fixed period or "pulse" of ½ second to 12½ hours, at continuously repeated intervals that are adjustable from ¾ second to 24 hours. By choice of load connection, control can be based either on the fixed pulse time or on the adjustable interval between pulses. Cycling period can easily be changed during operation.

ADJUSTABLE PERCENTAGE TIMER TYPE 610

Makes or breaks an electrical circuit for a variable percentage of a basic fixed cycle time. Desired percentage of total cycle time, for ON or OFF control of the timed device, is adjustable from 4% to 96% in steps of 1%. Total cycle-time ranges from 15 seconds to 24 hours. Internal connections can easily be arranged so that the load circuit is either closed or open for the indicated percentage of the full cycle.



CYCLING TIMER TYPE 571

Provides reliable and inexpensive control of repetitive switching for built-in applications. One through four poles, SPST or SPDT open-blade switches with contacts rated at 30 amperes, each controlled by a timing cam specially cut to user's requirements. 18 standard speeds from 1 rpm to ⅛ rpd, plus many special time ranges.

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What kind of man makes the best supervisor for a creative group? Here's an original report by 105 experts on creativity and creative thinking on the personal characteristics and working attitudes of

the *ideal* creative supervisor

part 1

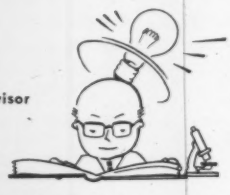
By EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

THE KEY FIGURE in inspiring high achievement and maximum creative performance from engineers or scientists is the immediate supervisor. His attitude can either stimulate or stifle potential creativity.

Much has been written on what is wrong with most scientific and engineering supervision. But it is easier to indicate what is lacking than to describe the ideal elements of the supervisor-group relationship. While the ideal is rarely attainable in practice, it serves as a very vital goal toward which the supervisor can strive.

To create a serviceable definition of the "ideal" supervisor of a creative group, the author, under the aegis of *Industrial Relations News*, an affiliate of Deutsch & Shea Inc., technical manpower consultants, asked 105 experts on creativity to list qualities of the ideal supervisor. The composite picture that emerges is presented for the first time in this series of three articles.

This composite picture goes beyond the specific research or engineering situation. The creative process, the experts agree, exhibits essentially the same dynamic pattern—independent of the particular field of research or inquiry the group is engaged in.



The Ideal Creative Supervisor Should

▶ Be Creative

Primarily, the ideal supervisor of a creative group, as indicated by the majority of the respondents, should be a creative person himself. Dr. Fred C. Finsterbach, an educational specialist, sees him as a man completely free of the disease of our age—conformity. "The ideal supervisor," he claims, "needs to be creative himself in the sense that he is free from the biases imposed by the need to conform." Professor Ross L. Mooney of Ohio State University visualizes him as a man deeply committed to a creative life:

> • *He understands the thrill of creation by having experienced it himself; he is as much interested in seeing that others experience this thrill as that he do so himself; experiencing life as a creative experience is more important to him as the core reason for living than is his fitting to any particular social forms of a given company or generation or culture. He lives big and deep as a man in relation to nature's problems.*

Most of the others agreed that he should have active, technical imagination of a high order, which should express itself in an ability to detect

The 105-man panel of experts . . .

. . . who provided the information for this survey are all connected with creativity in one form or another. They are researchers in creativity, teach creative thinking courses, serve as consultants to industry in creative research and management, or direct advanced research and development work. Many have made significant contributions to the understanding of creativity, and most have published articles and books on the subject.

The group included 82 individuals with universities, including 17 psychologists and social scientists, 2 psychiatrists, 7 professors of engineering and science, and others in fields like industrial management, industrial relations, education, marketing, humanities, and architecture. Eleven experts are with research foundations, independent research institutions, and consulting organizations. Most of the participants, however, are in industry: 33 serve as managers and directors of research and development, 16 are in charge of training and education and give courses in creative thinking techniques, 6 conduct personnel and management research, and the rest are practicing scientists and engineers.

and offer creative challenge to his group. He should be able to generate ideas himself and recognize the merits in a wide range of ideas.

As Dr. Elliot Danzig, former director of the Institute for Research in Human Relations, put it, "He should be able to visualize the possibilities inhererent in ideas that seem at first remote from the goals of the group." Professor Silvan S. Tomkins of Princeton University crystallized, what is, perhaps, one of the major values that can accrue to his being a creative person, namely, his "ability to inspire creativity through indentification."

The Ideal Creative Supervisor Should

Understand the Creative Process

In addition to his own creative ability, the ideal supervisor should have an articulate insight into the nature of the creative process. The importance of understanding the creative process is underscored in the following comments:

- *He should have deep faith that the contributions of the individuals cannot be predicted.*
- *He recognizes that creativity occurs in spurts.*
- *Rather than trying to eliminate the trials and frustrations of the creative process, the wise leader of a research program must try to understand this cycle, to nurse projects along, and to give the proper encouragement at the proper time.*
- *He should understand the basic psychological characteristics of creativity, some of the "blocks" which inhibit it, and some of the methods which can be used to release creative approaches in his employees.*

Understanding the nature of the "blocks" is particularly important, since limited creative performance is frequently not so much due to the absence of sufficient creative potential as it is to inner barriers to expression.

The supervisor should be able to define and recognize these emotional, cultural and perceptual blocks among his group of engineers and scientists. He should understand what causes them and how they prevent the emergence of novel thought. Only then can he undertake proper action for their removal by helping his people to establish new, more flexible patterns of behavior and thinking.

One of the major responsibilities of the supervisor should be to hold periodic meetings with his people where other difficulties can be frankly discussed. Due to the well-known reluctance of many technical creative people to introspect, effective insight into the impediments of unhampered creative thinking will not come easily. Open dicussions of the problems in the creative process, where everyone freely partici-

pates, are necessary. In brief, every scientist and engineer should be helped to become aware of most of the inhibiting blocks in his makeup so that each may overcome any emotional and mental barriers to creation.

The Ideal Creative Supervisor Should

▶ Understand Creative Temperaments

Together with an insight into the vagaries of the creative process, the ideal supervisor should have an objective, but always compassionate, understanding of creative people, their temperaments and motivations. He should have a tolerant and respectful awareness of individual differences among his subordinates. Dr. F. A. Cartier, an educational specialist, placed especially strong emphasis on the uniqueness of individuals:

- *The only true answer to the problem of managing creative people is to respect each one and to encourage each one to continue being the person he is. This calls for a supervisor who is willing to accept the long hard task of learning to understand his employees' powers and foibles, their motives, their fears, and their enthusiasms.*

Essentially the same point was made by Professor Mooney:

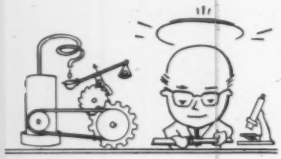
- *Different individuals have different ways in which they feel their creative spirit to be released. Helping a man to get the best out of himself means helping him to find and release his particular way.*

Thus, supervisors must not be afraid of their creative people, must not be jealous of them, and must truly want to see them succeed. Indeed, Dr. Franklin J. Shaw of Purdue University feels that the supervisor's catalytic role in creative research is even more important than the creative example he may set to his men:

- *The ideal supervisor should be one who can elicit the best performance from others much as an outstanding coach, teacher, or manager of a prize fighter or candidate for office does. Coaching or eliciting the best performance from others seems to me to be an important variety of human talent which is not necessarily too highly correlated with interpretive or creative thinking talent. This means that the ideal supervisor may not set an example of creative achievement, but serves instead as an important catalyst. I would envision him as being long on patience, encouragement, appreciation and satisfaction in seeing others perform well.*

One panelist, psychiatrist O. Spurgeon English stated, "The ideal supervisor also recognizes his great emotional significance to his team members and deals with this effectively." Dr. J. H. McPherson, a staff psychologist of Dow Chemical Company put it this way: "Much of what he sees in people and how he evaluates them is related to his own self-concept, his own value system, his own defense mechanisms, etc. Unless he understands himself pretty well he is apt to 'clobber' his men with his own prejudices." There was broad agreement that without such an insight into himself, the supervisor's attitudes and personality are apt to aggravate or reinforce the existing emotional peculiarities of at least some of his subordinates.

The Ideal Creative Supervisor Should



▶ Have High Technical Competence

A large number of panelists emphasized that the ideal supervisor should have high technical ability in his own right and a "feel" for creative technical work developed from first-hand experience. He should be a man able to inspire the confidence and respect of specialists in his field.

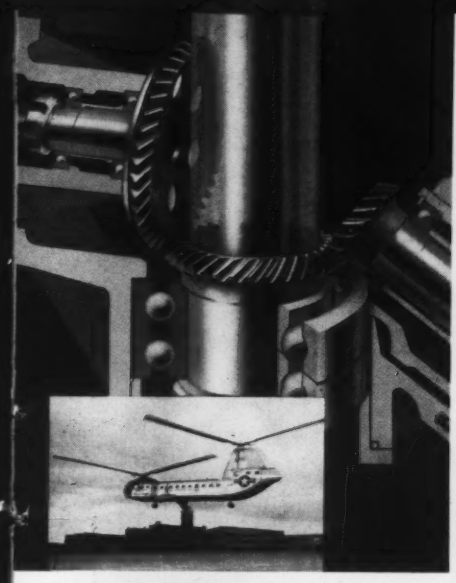
The only disagreement among the panelists who stressed the importance of technical competence was in the degree to which it should be present. Some felt that the supervisor should be recognized as a leader in his field, or at least have a considerable reputation. He should be, as one panelist succinctly described it, "persuasive by his authority of knowledge."

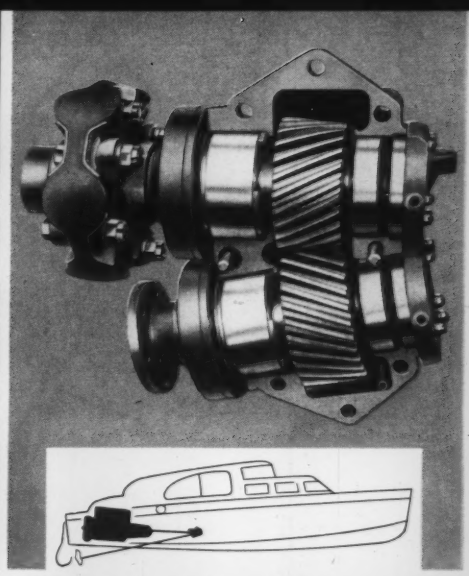
Others lowered their sights a bit, feeling that such a stiff requirement would be unrealistic. They indicated, however, that a good measure of technical soundness based on a breadth of experience in various sciences, rather than expertness in one specialty, would be desirable. At all times, however, as Dr. Leo Steig of General Electric Company stated, "he must be conversant with the scientific aims of his group." W. F. G. Swann, director of Bartol Research Foundation, amplified this view:

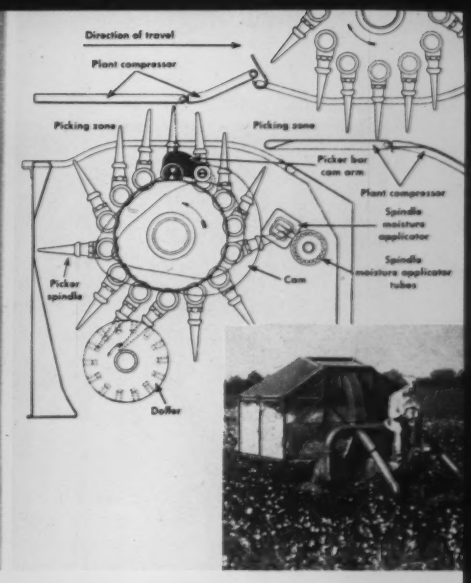
- *The supervisor should be a man who, while not necessarily as up-to-date in every detail of some of the activities as may be those whom he is supervising, has nevertheless the power to enter personally into the field at any one point, and be of help to a scientific man in the region of that man's own specialty even though the man himself may be much more familiar with many of the details than the supervisor is. Unless the supervisor has this background of fundamental power, he is in my judgment of very little use.*

Many other panelists also felt that no specialist mentality can progress very far creatively unless it is a mind versed in many fields beyond its own particular specialty. Technology has evolved to such a degree of complexity and difficulty that it takes an active, inquisitive, and expansively interested person who studies, reads and experiments in many diverse fields, to make significant scientific advances. The creative scientist, for instance, certainly has to be a specialist and thoroughly immersed in one field. But this has to be counterbalanced with a breadth and versatility of experience and knowledge. He has to be a specialist who is also a generalist.

Next article in this series will appear in the October 4 issue of MACHINE DESIGN.







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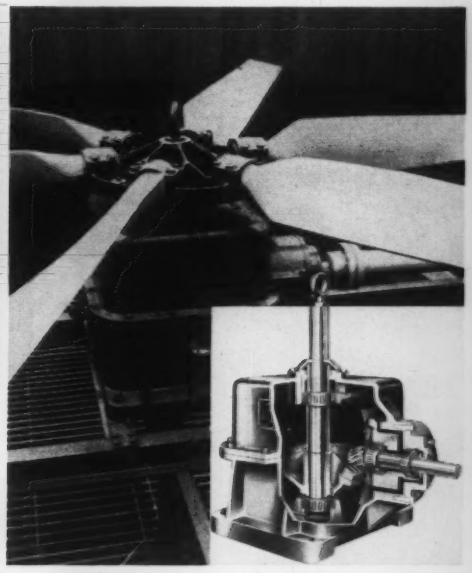

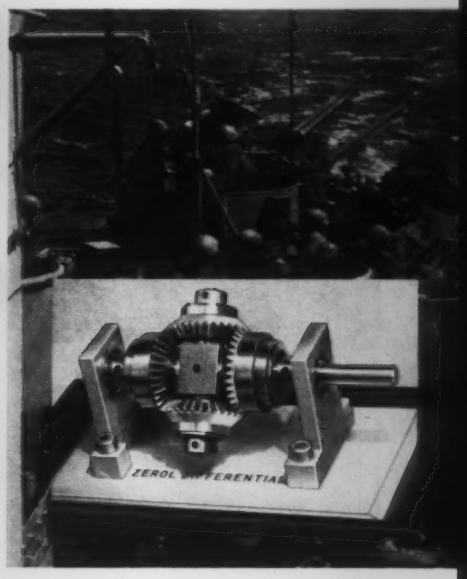

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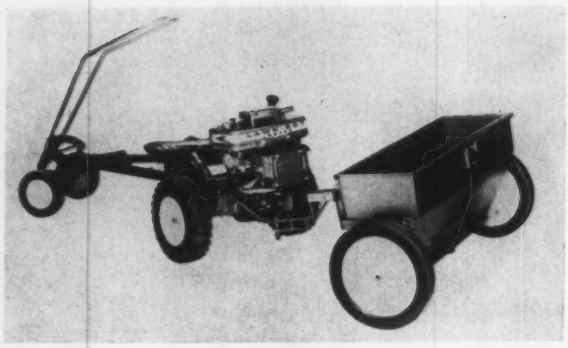
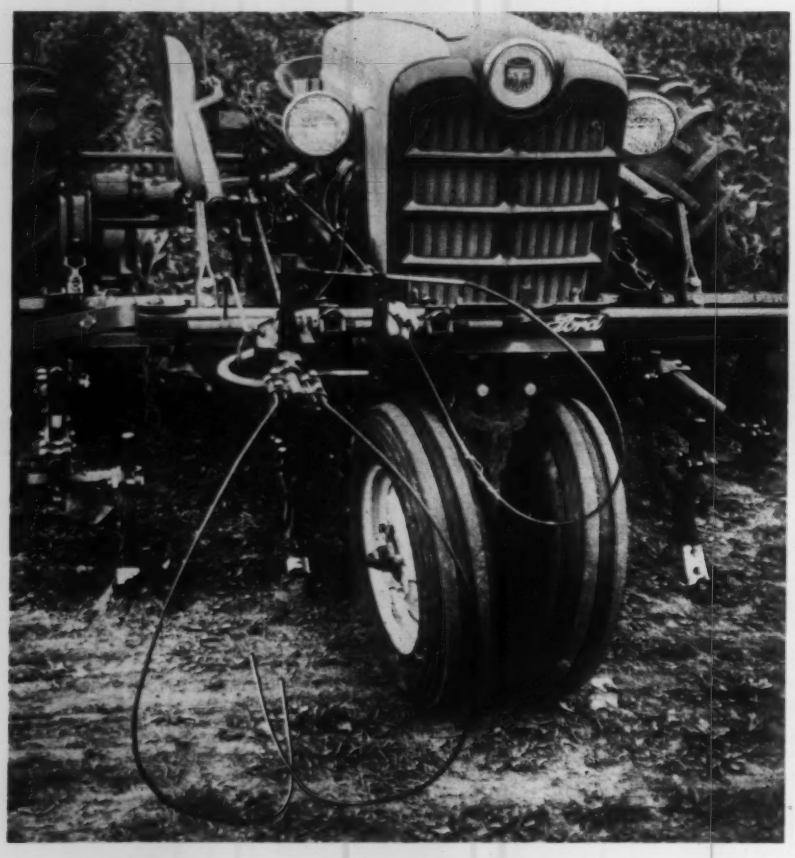


BACKYARD DOZER AND PICKUP TRUCK are two of many configurations possible with a 2½-hp prime mover called the Loafer. Gear ratio of 47:1 enables the low-slung tractor to pull 1-ton loads or push big rotary motors. It has four speeds forward plus reverse, and a top speed of 4 mph. Squat silhouette—22½ in. —provides the desired low center of gravity, permits out-of-the-way vertical storage in crowded garages. Built by Lawn-Boy Div., Outboard Marine Corp., Loafer also features automobile-type steering, with quick self-centering steering-wheel response. The vehicle is constructed of steel and aluminum; weighs 100 lb. In industrial applications, Loafer is used to pull pallets and equipment when not cutting the company lawn.

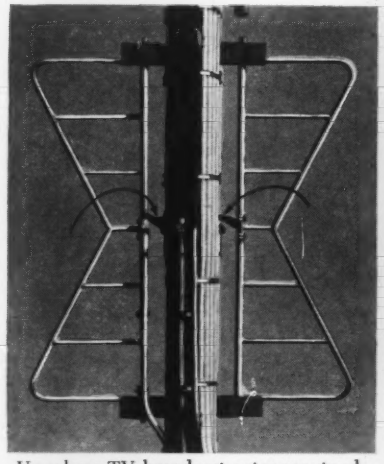


AUTOMATION DOWN ON THE FARM takes a big step forward with Ford's new robot cultivator. It's held on course by an autopilot that permits hands-off steering at cultivating speeds up to 6 mph. Guidance of the unique machine is provided through an insect-like feeler projected dead ahead of the tractor. Movement of the feeler, caused by brushing against small plants, activates sensitive switches controlling a small electric servomotor in the tractor's power-steering linkage. This automatically steers the tractor, keeps the cultivator centered in the crop row, and relieves the farmer of an otherwise tedious job.

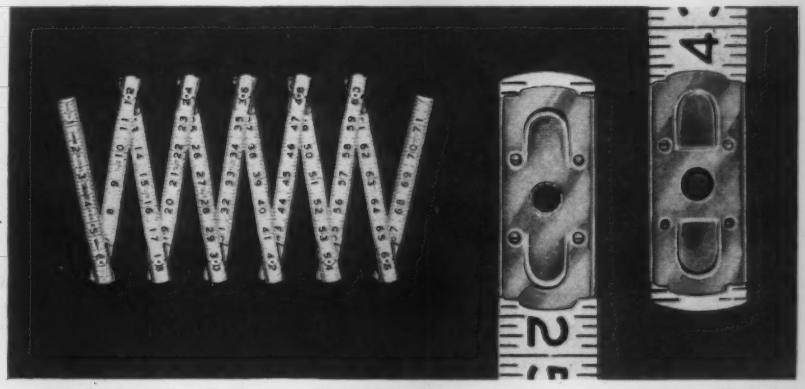
BETTER TV RECEPTION is claimed possible with two new TV tubes which use this frame grid construction. Tungsten wire, 0.00029 in. in diameter, is wrapped around the frame of two centerless-ground molybdenum rods. The rods, which can be made to a tolerance of 0.00019 in., determine clearance between the turns of wire on opposite sides of the frame. This clearance and its accuracy largely determines the grid-cathode spacing, which in turn determines gain-bandwidth product and transconductance. The result: Noise is appreciably lower than with current tubes. This means that TV signals can be picked up reliably in areas where reception is difficult, and in fringe areas where reception is only possible with the use of tall towers and elaborate high-gain antennas. Amprex Electronic Corp., Hicksville, N. Y., developed the frame grid for 6ES8 and 6DJ8 tubes. Service life of the new tubes is said to be greatly increased.

TRY A FRESH APPROACH

Don't just take your metals for granted—specify the properties you need. The Man from Anaconda may come up with some very interesting answers.



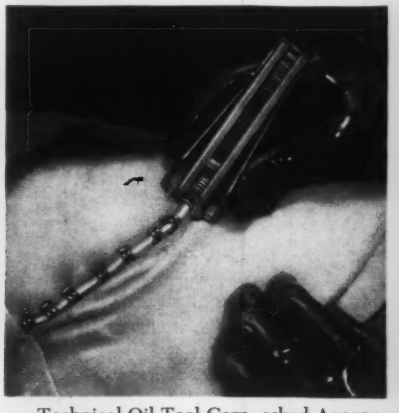
Up where TV broadcast antennas stand, normal wind causes flexing of metals. So jumpers between coaxial cables and radiators must be resilient – beside being conductors, giving some structural support. Ordinary phosphor bronze seemed adequate, but there were fatigue failures.



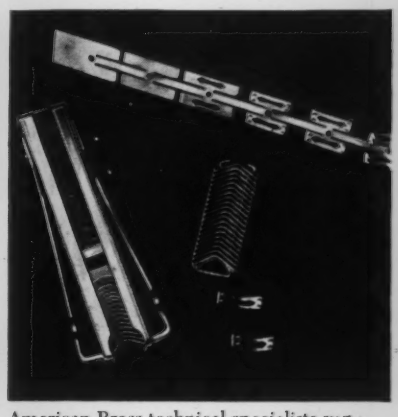
To stimulate sales of its top-quality folding rule, and to meet Navy specifications, Eagle Rule Mfg. Corporation sought a metal for rule joints that would resist wear and corrosion, and provide the proper spring tension. Phosphor bronze, which had these qualities in excess of needs, cost too much.

American Brass suggested three alloys. Eagle Rule chose Ambronze-420 (88 Cu, 11 Zn, 1 Sn) because rule joints of this alloy met all requirements, withstood 400,000 cycles in wear test (Navy required 7000). It cost only pennies per pound more than yellow brass, much less than phosphor bronze.

RCA listed desirable properties of phosphor bronze – added *extra*-high endurance, *extra*-long fatigue life. American Brass suggested Duraflex®, Anaconda superfine-grain phosphor bronze. RCA tried it, found it the answer—at no extra cost—specified Duraflex to the manufacturer, Dielectric Products Engineering Co., Inc., Raymond, Maine.



Technical Oil Tool Corp. asked Anaconda to help select the metal for a new magazine-type clip used to close surgical incisions. The metal had to provide the right tension to hold edges together, yet open easily—form readily, hold sharp die-cut edges, be proved in surgical use.



American Brass technical specialists suggested Nickel Silver, 18%-719 as best suited to meet all requirements. Autoclip, shown in use above, is the result. Incisions are held together with least damage to tissues. Surgeons can work faster in applying and removing clips.

STARTING with 93 standard alloys, The American Brass Company can make minor variations in composition, fabrication, and annealing to provide an almost unlimited number of combinations of useful properties. When new or unusual problems arise, ask for the help of the Technical Dept. in selecting the right metal. For such help or a copy of Publication B-32, "Anaconda Copper & Copper Alloys," write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario, Canada.

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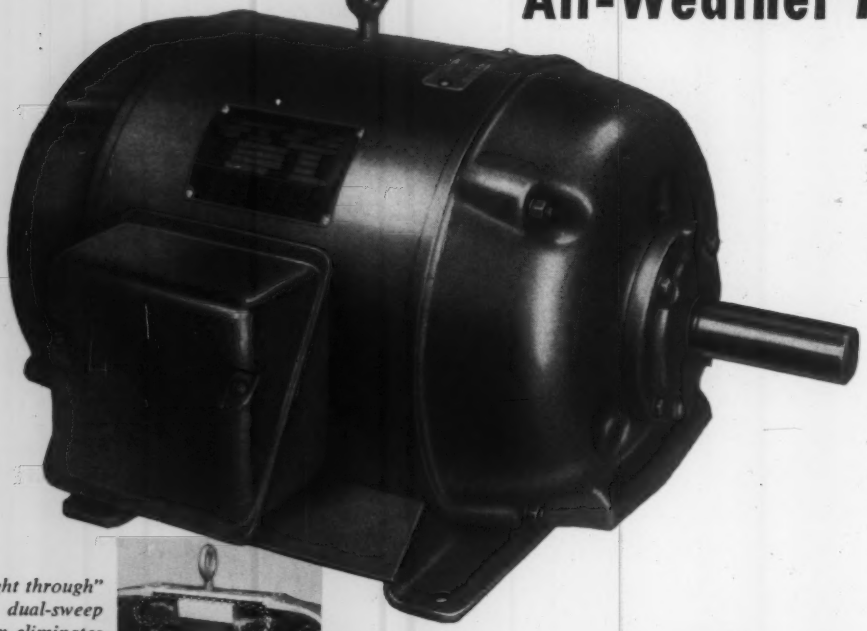
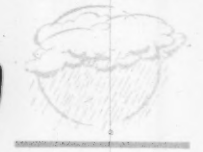
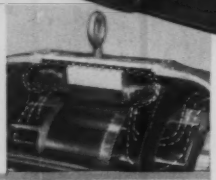
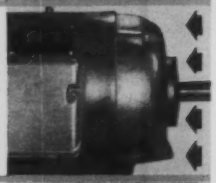




"straight through" dual-sweep ventilation eliminates "hot spots"



full height end head protection



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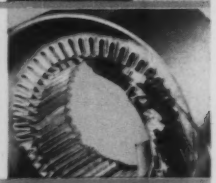
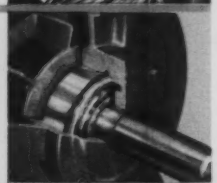


bearings easily inspected by removing cover plate



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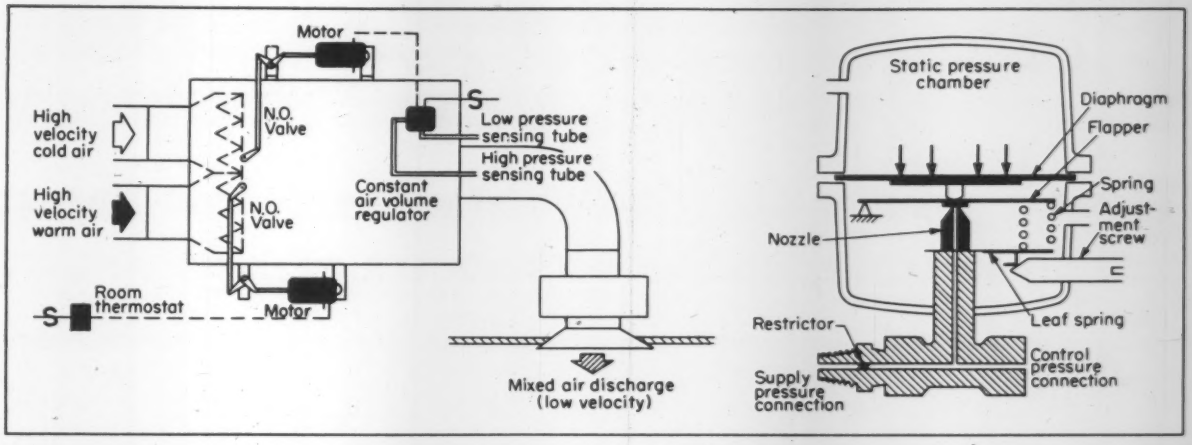
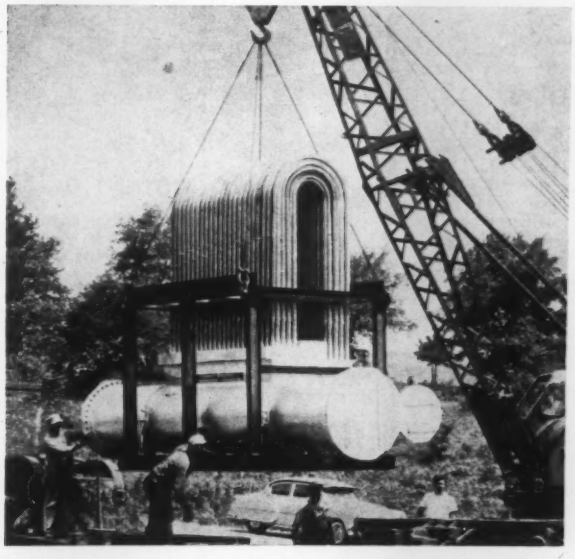


SYSTEM BALANCING IS NO PROBLEM where hotel, hospital, or office-building air-conditioning systems are under the control of a new static-pressure regulator. Called CAV (for constant air volume), the regulator senses static pressure in a mixing box, holds low-velocity air flow from box to room constant regardless of changes in the hot or cold air supply. In arrangement shown here, the room thermostat adjusts position of the hot-air valve; the CAV regulator holds the rate of mixed air discharge to the room constant by opening or closing the cold-air valve. Made by the Powers Regulator Co., Skokie, Ill., the unit eliminates air-conditioning balancing problems, since the flow rate set for one room is completely unaffected by conditions in other rooms. In operation, the CAV regulator is a constant-waste device. When controlling at its set point, the nozzle leaks air at a rate which maintains set pressure in the control line. When mixing-box static pressure increases, for example, the CAV diaphragm moves the flapper closer to the nozzle, reducing nozzle leakage and raising control-line pressure. Sequence of operation is reversed for a falling static pressure.

Superlatives in Stainless . . .

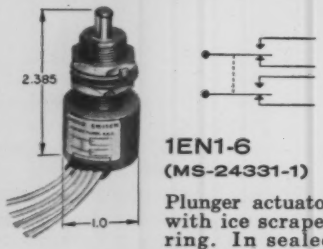


SIX MILES OF STAINLESS STEEL TUBING heat 2 million pounds of air per hour in a heat exchanger built for a gas-turbine engine test program. Made up of four stages like this one, the exchanger requires heat from 24 high-velocity oil burners to raise temperature of the air from 350 to 700 F. Threat of carbide precipitation and corrosion in conventional stainless dictated the use of Type 321 stainless stabilized with titanium. Design and fabrication of the exchanger was by Thermal Research and Engineering Corp., Conshohocken, Pa.; tubing by Carpenter Steel Co.

RETUBING WITH 9234 STAINLESS STEEL TUBES will triple the life expectancy of this steam condenser in Monongahela Power Company's Rivesville Station. Thick-wall nonferrous tubes replaced by the stainless tubes had a life of about ten years; new Type 304 stainless tubes, supplied by Allegheny Ludlum Steel Corp., are expected to last 30 years. Unit passes 45,000 gpm of Monongahela River cooling water (pH value = 2.8) in condensing 115 F steam to water. When unit is eventually cleaned, average performance level is expected to be raised enough to pay for cleaning.

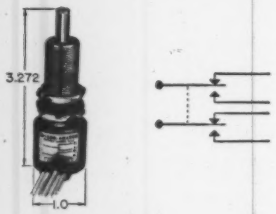
MICRO SWITCH Precision

These Switches Reliably Perform Over Rockets...Missiles...Launchers...



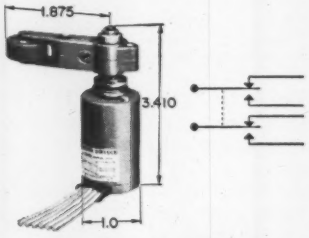
1EN1-6
(MS-24331-1)

Plunger actuator with ice scraper ring. In sealed enclosure are two SPDT subminiature basic switches. Operating force 6-12 lbs.; release force 4 lbs.; overtravel—.250 in. Rating: 28vdc 24a. inrush; 4a. resistive; 3a. inductive. Weight—2.5 oz.



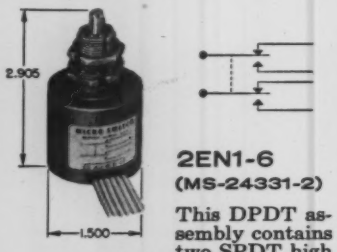
1EN61-6

The longer bushing provides maximum adjustment range of operating point. Overtravel—.500 in. DPDT circuitry and capacity same as 1EN1-6.



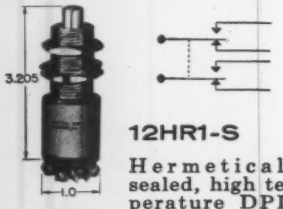
31EN1-6

Adjustable spring-return rotary actuator. Contains two "SM" switches (See 1EN1-6). Operating torque 30 in. lbs.; release torque 9 in. lbs.; total travel 45°.



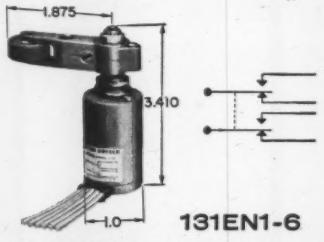
2EN1-6
(MS-24331-2)

This DPDT assembly contains two SPDT high capacity "V3" type switches. Rating: 28vdc—36a. inrush; 10 a. resistive; 6a. inductive. Operating force—6 to 12 lbs.; release force—5 lbs.; overtravel—.250 in. Weight 5.5 oz.



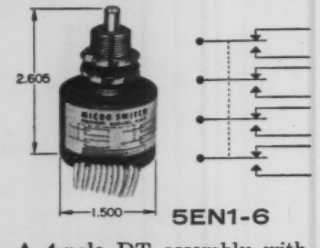
12HR1-S

Hermetically sealed, high temperature DPDT switch for reliable use to 600° F. Metal-to-metal & glass-to-metal seals in accordance with Par. 5.2.2, MIL-E-5272A. Ice scraper ring on actuator. Rating 28vdc-5a. res.; 2a. ind. Operating force 6-12 lbs.; release force 5lbs.; overtravel—.250in. Weight 4.5 oz.



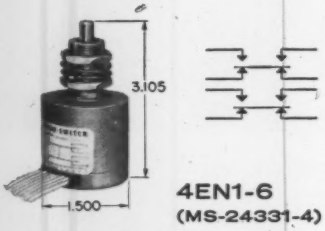
131EN1-6

Special high temperature construction for up to 250° F. Adjustable spring return rotary actuator. DPDT. For rating see 1EN1-6. Operating force 30 in. lbs.; total travel 45°; differential travel 6°. Weight 2.65 oz.



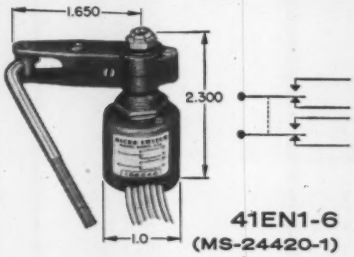
5EN1-6

A 4-pole DT assembly with 4 SPDT "SM" basic switches sealed in enclosure only 1½" dia. Mechanical characteristics same as 1EN1-6 except differential travel. 28vdc—24a. inrush; 4a. resistive; 3a. inductive. Weight 4.25 oz.



4EN1-6
(MS-24331-4)

Sealed within the 1½" dia. enclosure is one 4-circuit double-break "TB" series switch. Rating 28vdc—30a. inrush; 15a. resistive; 10a. inductive. Operating force—6-12 lbs.; release force—5 lbs.; overtravel—.250 in.

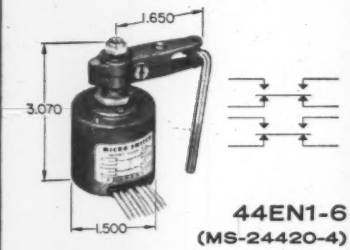


41EN1-6
(MS-24420-1)

Has rotary actuator with linkage for positive drive and release. Lever arm adjustable through 360°. Two SPDT "SM" switches in sealed enclosure provide DPDT circuitry. Operating torque—3 in. lb.

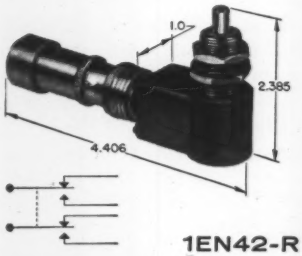
Switches have uses unlimited

350 Functions in Aircraft... Marine and Ordnance Applications



44EN1-6
(MS-24420-4)

Rotary actuator arm adjustable through 360°. Contains one 4-circuit basic switch. Rating 28 vdc—30a. inrush; 15a. resistive; 10a. inductive. Operating torque —10 in. lbs.



1EN42-R

A special design for high shock applications. Contains two SPDT switches. See 1EN1-6. Quick disconnect connector.

1LS1

Versatile, sealed indicator and limit switch for launching equipment. Head adjusts to 4 positions; arm adjusts through 360°; operation adjusts to either or both directions. Two-circuit basic switch. Rating: 10a. 120, 240, 480vac. Operating force 3 lbs.; release force ½ lb.; overtravel 30°.

For many years, MICRO SWITCH's Airborne Projects Group have been answering your questions and helping you solve difficult problems by cooperative engineering help and a readiness to design special switches for you.

The twelve "EN" Series switches illustrated in these pages are the outgrowth of one switch. The "EN" Series has now grown to a point where the series consists of ninety-four different switches actually in use—an original concept by the Airborne Projects Group at MICRO SWITCH.

"EN" switches are completely sealed against the effects of changes in atmospheric conditions in enclosures filled with inert gas under pressure. Each switch is fabricated under rigid manufacturing procedures, and tested on a mass spectrometer. The actuator mechanism operates through a seal that maintains pressure and keeps dust and moisture out. A scraper ring on the actuator shaft prevents jamming or binding even in ice or mud . . . Your request for catalog 77 and data sheets 122 and 138 will be responded to promptly.

MICRO SWITCH . . FREEPORT, ILL.
A division of Honeywell
In Canada: Honeywell Controls, Ltd., Toronto 17, Ontario

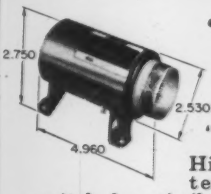
The two-word name MICRO SWITCH *is* NOT *a generic term. It is the name of a division of Honeywell.*

Look in the Yellow Pages for the name of the branch office and sales engineer nearest you.

Honeywell
MICRO SWITCH PRECISION SWITCHES

121EN18-R

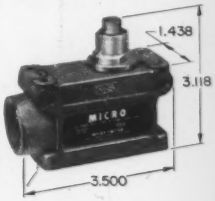
Roller plunger adjustable in increments of 45°. "AN" receptacle. High temperature construction for up to 250° F. Contains two gold-contact "SM" switches. Characteristics same as 1EN1-6.



24 SEPARATE SPDT CIRCUITS

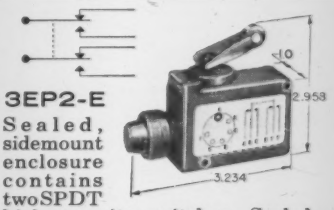
1RS1
"Rotoswitch"

High reliability telemetering switch for missile program sequencing. Hermetically sealed enclosure contains rotary solenoid and 24 SPDT gold-contact "SM" switches.



4CE1

Rugged indicator or limit switch for missile shelter, erecting and launching equipment. SPDT. Rating: 10a. 125vac; 5a. 250vac. Operating force 6-10 lbs.



3EP2-E

Sealed, sidemount enclosure contains two SPDT high capacity switches. Sealed receptacle. Rating: 28vdc-36a. inrush; 10a. res.; 6a. ind. Operating force 4-6 lbs.; release, 2 lbs.

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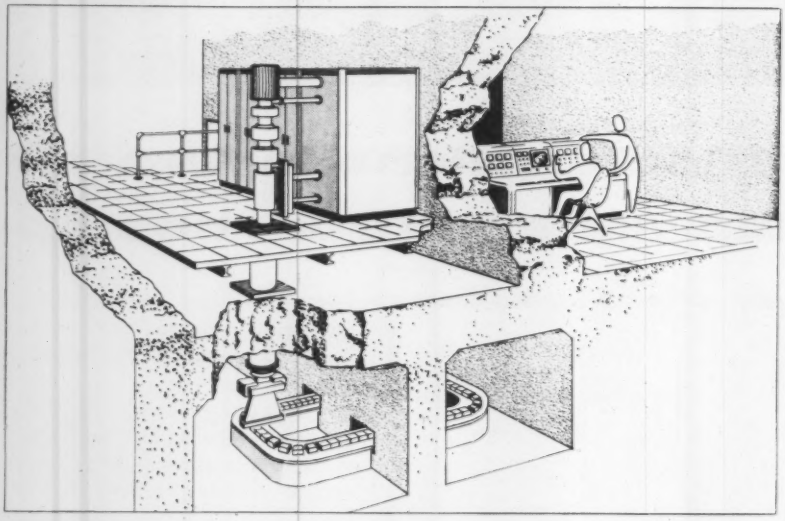


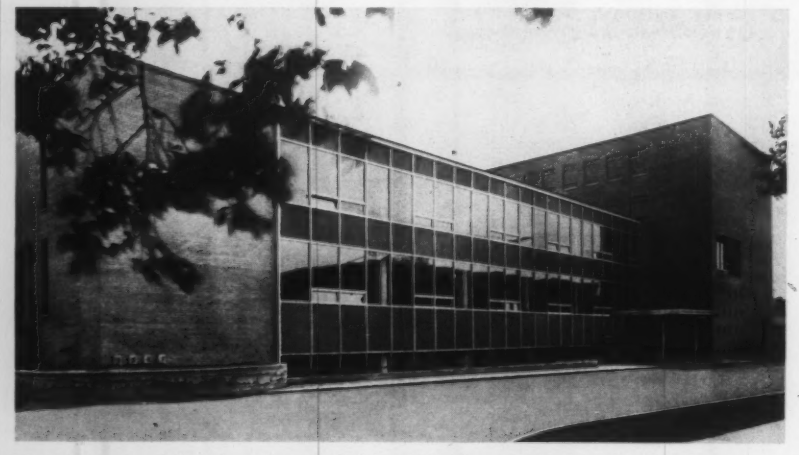
LINEAR ELECTRON ACCELERATOR produces ionizing radiation for large-scale processing of foods, chemicals, and fabricated polymers. Demountable construction and the ability to be integrated into multiunit complexes are features of the new Mark 20-J21 accelerator. The 10-million v, 21-kw accelerator, designed by Applied Radiation Corp., Walnut Creek, Calif., can be ganged into integrated systems for control by one operator.

New Tech Center Completed For Cleveland Engineers

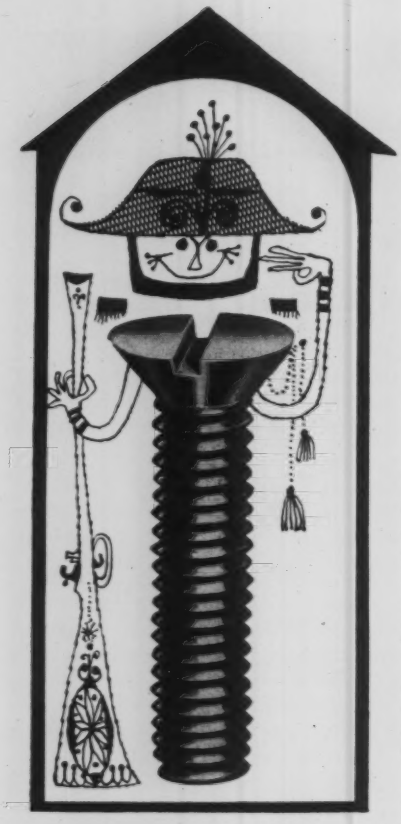
CLEVELAND—Open for "business" this month is an impressive $1.5 million building with an equally impressive name: Cleveland Engineering & Scientific Center. Proud owner is the Cleveland Engineering Society, which sees the center providing a "professional roof" for engineering in all its phases.

That the center serves this aim is apparent. It offers local engineers facilities for meetings, conferences, exhibits, and classes. Scheduled for the rest of this year are 200 meetings of technical groups other than CES itself. The center is available to all 52 members of the Cleveland Technical Societies Council, including local chapters of societies such as ASME, AIEE, SAE, and ASTM.

Activities of CES will increase in its new and larger quarters. All of its five divisions will hold all-day



New Cleveland Engineering and Scientific Center, located in the downtown area, has auditoriums, exhibit space, lounge, dining rooms, and offices of the Cleveland Engineering Society. Largest of three auditoriums seats 1200.



GUARD AGAINST CORROSION WITH ALCOA ALUMINUM FASTENERS

Whatever you make, make it better of aluminum and fasten it with Alcoa® Aluminum Fasteners. Guard against both galvanic and atmospheric corrosion and get lasting sales appeal with bright, carefree aluminum fasteners. For your requirements, call your nearest Alcoa sales office. Complete stocks of all standard types and sizes of Alcoa Aluminum Fasteners are on hand at your local Alcoa distributor. Look in the Yellow Pages of your telephone directory.

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Your Guide to the Best in Aluminum Value

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Aluminum Company of America
2244-J Alcoa Bldg., Pittsburgh 19, Pa.

Gentlemen: Please send complete specification data and samples of Alcoa Aluminum Fasteners.

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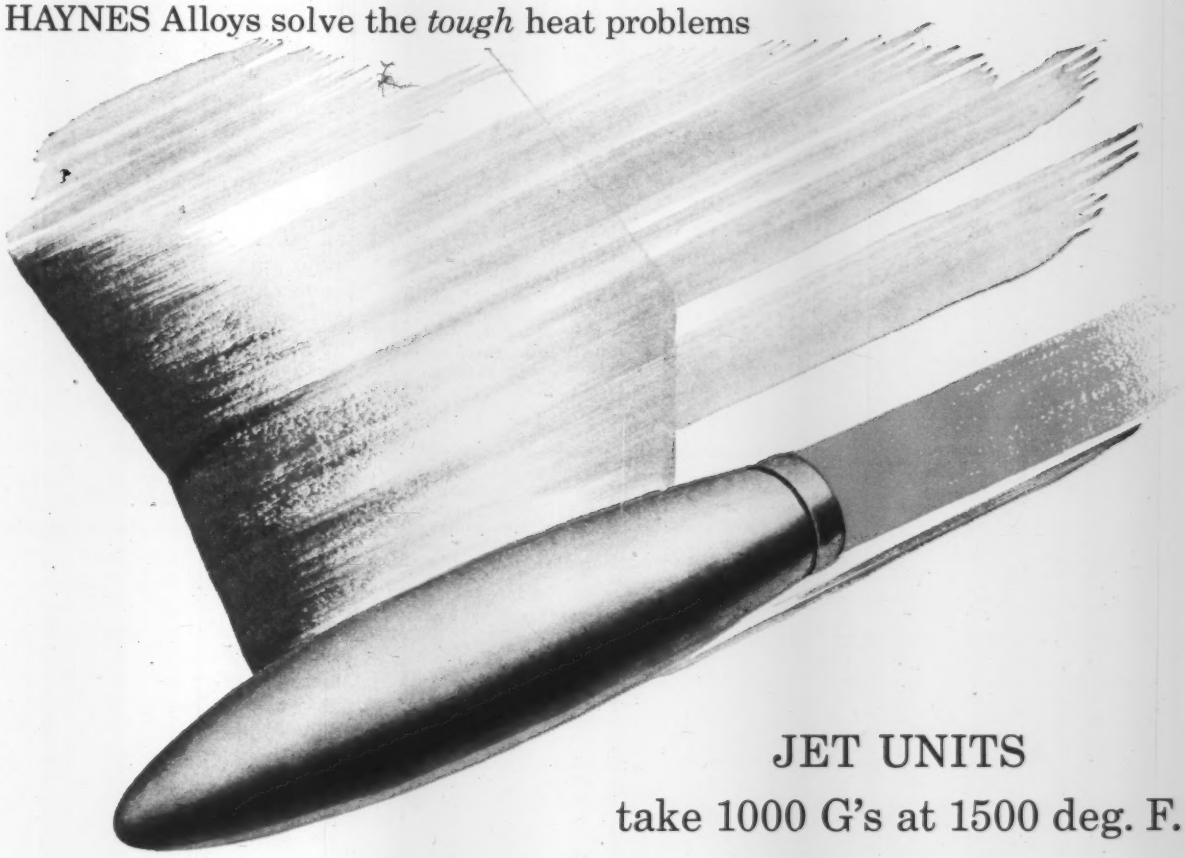
Title_____

Company_____

Address_____

Circle 418 on Page 19

HAYNES Alloys solve the *tough* heat problems



JET UNITS
take 1000 G's at 1500 deg. F.

Mounted to the tips of the rotor blades of a new type aircraft are small pressure jet engines encased in shells of HASTELLOY alloy X. In flight, these jet units are subjected to extremes in stress and heat. HASTELLOY alloy X was selected for the shell material because of its high strength at temperatures in excess of 1500 deg. F. and because it is readily formed and welded.

If you have a high temperature or a difficult design problem, contact our nearest sales office, or write HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana. Sales Offices in Chicago, Cleveland, Detroit, Houston, Los Angeles, New York and San Francisco.

XV-1 Convertiplane in history-making flight ... HASTELLOY alloy X sheet was dished and welded to form the shell of the jet units mounted to the tips of the three rotor blades.

HAYNES
ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

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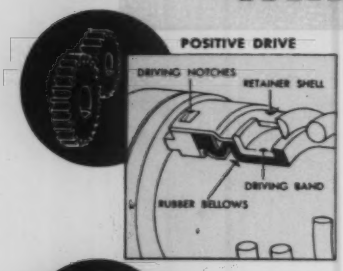
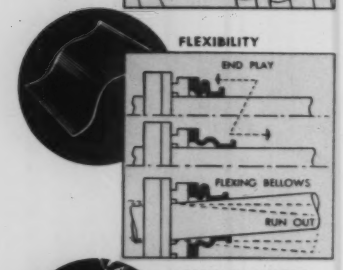
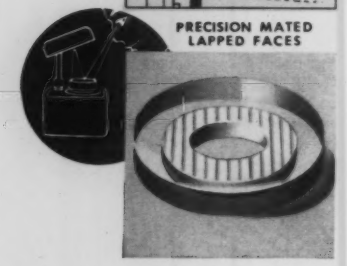
Circle 419 on Page 19

JOHN CRANE Shaft Seal Design With A Purpose!







POSITIVE DRIVE

This gives long seal life. Drive is transmitted through the driving band and washer driving notch which absorb all breakout and running torque. Damaging stresses on the bellows or flexible sealing member are eliminated. Slippage is also eliminated, thus protecting shaft or sleeve against galling.

FLEXIBILITY

Axial and radial misalignment problems are eliminated. Self-adjusting bellows or sealing head automatically compensates for shaft end play or run out. Minimum spring pressure is required for axial shaft movement and uniform spring pressure is maintained during radial shaft movement.

PRECISION MANUFACTURE

Leakproof performance is assured. Washer and seat surfaces are precision lapped to a perfect mate under a patented "John Crane" process.

A SEAL FOR EVERY SERVICE

All "John Crane" Seals are constructed to the particular service requirements . . . from hot or cold water to the most destructive acids, corrosives and gases . . . temperatures up to 1000°F. . . . pressures to 1200 psi. They can be furnished in types and sizes to meet practically any mechanical or dimensional condition.

Request Bulletin S-204-2. Containing full information on "John Crane" engineered shaft seals.

GET COMPLETE DETAILS

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(Chicago Suburb)

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JOHN CRANE
MECHANICAL PACKINGS | SHAFT SEALS | TEFLON PRODUCTS | LAPPING MACHINES | THREAD COMPOUNDS
CRANE PACKING COMPANY

Circle 420 on Page 19

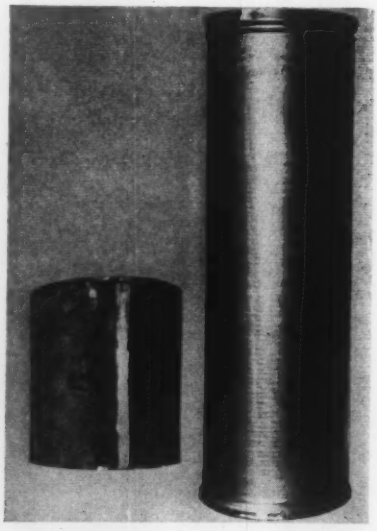
meetings in the coming year. Evening education for technical people in the Cleveland area is offered by ten courses ranging in subject from Creative Thinking to Machine Drives and Controls.

Establishment of a common meeting place for engineering and scientific groups appears to be a trend. Centers similar to the one in Cleveland are being built in other large cities, including New York, Philadelphia, Boston, Baltimore, Cincinnati, St. Louis, Houston, Atlanta, and Kansas City, Kans.

New Air-Hardenable Steel Has 280,000 psi Tensile Strength

PITTSBURGH—Cooling in the open air hardens a new ultra-high strength alloy sheet steel to 280,000 psi tensile strength. Oil or salt quenching are eliminated. The steel has excellent weldability and is easily formed.

Called Airsteel X-200, the new alloy was developed at U. S. Steel's Research Center in Monroeville, Pa. It is described only as a well-balanced combination of alloying elements which have proved suitable



Fabricability tests of Airsteel X-200 included shaping the alloy into a 1/4-in. thick welded cylinder blank, left, and hydrospinning the blank to produce an 0.080-in. thick cylinder, right. Longitudinal weld is shown in both views. Tensile strength of the finished cylinder is in the 280,000-psi range.

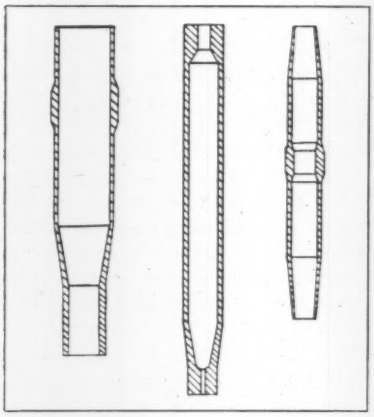
for rendering steel air-hardenable. Commercial heats have been produced or processed at several of the company's mills.

Fabricability tests with Airsteel have included forming, fitting up for welding, heat treating, and hydrospinning. Weldability studies show that welded joints are equal in strength to the metal being joined. Regular production methods of metallic-arc and inert-arc welding were used.

First products made with the new alloy were large-diameter, thin-wall missile-motor cases, with and without longitudinal welds. This application was the specific goal of the 2-yr old Airsteel research program.

A typical motor case is formed and welded in the annealed condition, heated to an established temperature, and allowed to air cool at room temperature. A tempering treatment at a lower temperature, followed by air cooling, gives the metal ductility and toughness.

The alloy is produced in billets, blooms, bars, plates, and sheets.



DESIGN IS SIMPLIFIED when fabrication of tubular parts is done by Flotrusion and metal-gathering, according to Thompson Products Inc. End fittings and welded or brazed joints are eliminated. One-piece parts in highly irregular shapes and sizes are produced rapidly to close dimensional tolerances. Materials being used are alloy steels, aluminum, titanium, and zirconium. Parts produced by the combined processes include hydraulic pistons, hollow bolts, and rocket-motor tubes.

FOR BETTER
product appearance
FOR FAST
low cost assembly

RECESSED TYPE
Recess avoids clogging of threads by weld flow or spatter—no re-tapping.

PILOT TYPE
Provides quick, accurate positioning. Pilot forms barrier preventing weld spatter in threads.

M·F
projection weld nuts

Solve production delays—cut manufacturing costs. Fuse nut to the product in exact location. Engineered for assembly simplification. The welding of nuts to sub-assemblies permits the use of screws or bolts in the main assembly without the need for holding nuts from turning, cutting time and labor.

Both types available with the patented *M·F Two-Way*® or famous *M·F UNI-TORQUE*® locking feature.

M·F weld projections are uniform in height and volume of material to insure uniform electrical contact and result in clean, strong, dependable welds.

M·F weld nuts are designed to give a 3-point bearing, eliminating rock and guaranteeing a uniform weld.

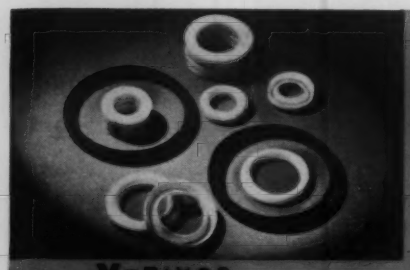
Concealed fasteners for improved product appearance.

Pre-attached fasteners in blind locations for faster, trouble-free final assembly . . . improve design . . . cut costs.

Send for descriptive literature.

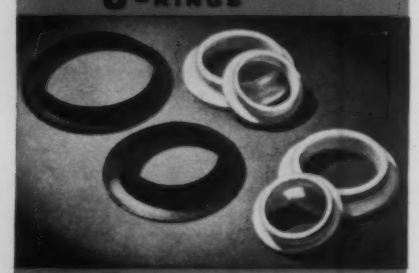
MAC LEAN-FOGG LOCK NUT COMPANY
5535 N. Wolcott Street, Chicago 40, Ill.

Circle 421 on Page 19



Chemiseal® hydraulic seals . . .

MADE OF
du Pont
TEFLON
T.F.E. fluorocarbon plastic



Chemiseal hydraulic packings are made for every type of static and dynamic seal. They are available in pure TEFLON or in Filled TEFLON (glass, graphite, etc.) depending upon the application and service requirement.

Preferred by Leading Engineers

Because Chemiseal hydraulic seals provide the reliability of chemically impervious TEFLON, they are preferred by leading engineers for maximum security at vital points in aircraft and missile, automotive, marine, ordinance and industrial hydraulic systems.

Outstanding Advantages

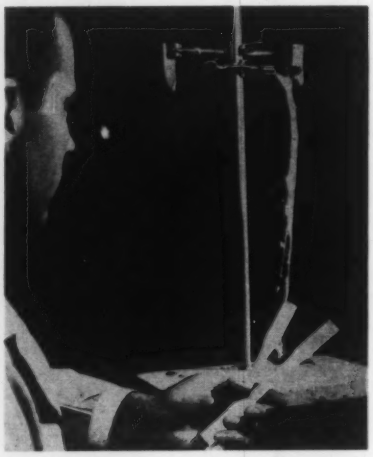
Chemiseal hydraulic packings require no chemical inspection, have zero swelling in all hydrocarbons, new synthetic hydraulic fluids and solvents.

They offer unsurpassed antifriction properties, are tough, resilient, non-flammable, long wearing. They function equally well at any temperature from 100 degrees below zero to 500 degrees above.

Write for further information and samples for test.

United States Gasket Co.
Camden 1, N.J.

United States Gasket *Plastics Division of* **GARLOCK**



NEW DESIGN APPLICATIONS for polyethylene plastic are foreseen with the development of a high-density, fire-retardant formulation. Offered in 10 colors by W. R. Grace & Co., Clifton, N. J., the new compound has electrical and mechanical properties which suit it for use as television-tube yokes, high-voltage sockets, air ducts, and other specialized applications. Flame-retardant sample shown here (left) is self-extinguishing after removal of flame; ordinary polyethylene (right) continues to burn.

Wax jobs last three years with a new high-metallic enamel developed by Chrysler Corp. The glossy finish will appear in a bright variety of colors on the company's 1959 cars. Aluminum particles are used for up to 100 per cent of the pigment. In previous paints, the aluminum ratio was limited to 60 per cent. As a base for the finishes, the company also developed a new primer. Epoxy resins are

Circle 422 on Page 19

used in the place of alkyd resins, to give the undercoat greater elasticity. This improves resistance to chipping and cracking. In tests, Chrysler painted metal panels with old and new finishes and left them at test farms in Florida. At the end of a year, older enamels reflected only 12 per cent of the light falling on them, while the new enamel reflected 76 per cent.

Meetings

AND EXPOSITIONS

Sept. 29-Oct. 1—

National Power Conference to be held at the Statler-Hilton Hotel, Boston. Sponsors are the power divisions of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 29-Oct. 3—

American Society of Tool Engineers. Semiannual Meeting and Western Tool Show to be held at the Shrine Exposition Hall, Los Angeles. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

Sept. 29-Oct. 3—

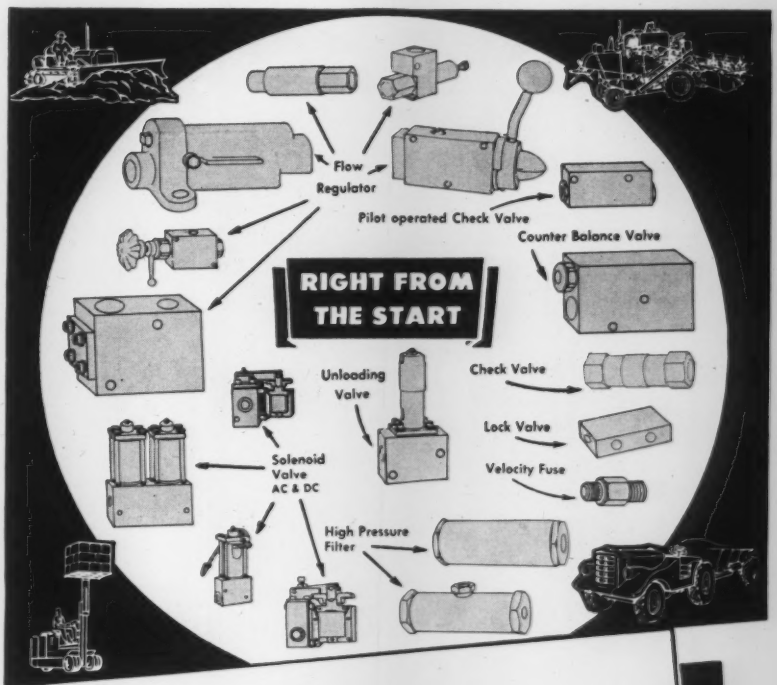
Society of Automotive Engineers. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at the Ambassador Hotel, Los Angeles. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

Oct. 7-8—

Institute of the Aeronautical Sciences — Canadian Aeronautical Institute Joint Meeting to be held at Chateau Laurier, Ottawa, Canada. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Oct. 8-10—

Gray Iron Founders' Society. Annual Meeting to be held at the



CONTROLLING FLOW IS OUR BUSINESS

All of the above valves have been used in various types of applications, including Material Handling, Road Building, Machine Tools, Farm Equipment and Earthmoving.

Waterman Engineering Company has also supplied valves to the Military for Ground Support Equipment and Missile Launchers.

We invite you to send us your applications and take advantage of our experience to help analyze your problems.

Bulletins of any of these products sent on request.

Also suppliers of AN and MS qualified Flow Rate and Volume Controls to the Aircraft Industry.

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725 CUSTER AVENUE · EVANSTON, ILLINOIS

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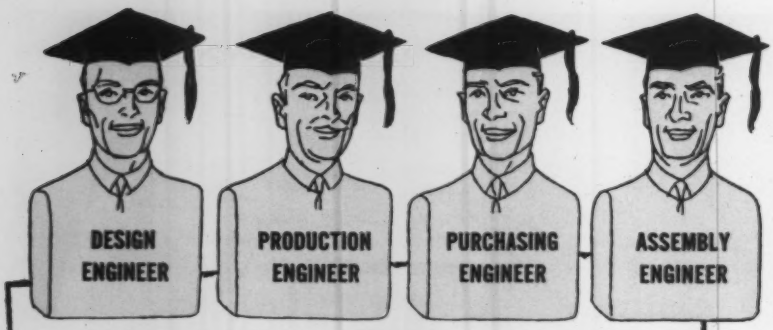

THOSE IN THE KNOW, KNOW

There's **NO** time waste

There's **NO** machining

There's **NO** grinding

There's **NO** counting

There's **NO** stacking

There's **NO** miking

and there's NO dirt between layers—ever, for those who say

YES to...

Laminated Shims of **LAMINUM** now available in

LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

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STAINLESS STEEL	ALUMINUM	BRASS	MILD STEEL
with laminations of .002" or .003"	with laminations of .003" only	with laminations of .002" or .003"	with laminations of .002" or .003"

LAMINATED SHIM COMPANY, INC.
Shim Headquarters since 1913
1209 UNION STREET, GLENBROOK, CONNECTICUT

Sheraton Park Hotel, Washington, D. C. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 14, Ohio.

Oct. 8-10—

Industrial Designers Institute. Design Materials Show to be held concurrently with the annual National Conference of IDI at the Sheraton-East Hotel, New York. Additional information can be obtained from Mr. Leonard Rogers, Orkin Expositions Management, 19 W. 44th St., New York, N. Y.

Oct. 13-14—

Fifth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Further information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 13-15—

American Institute of Electrical Engineers Tenth Annual Machine Tool Conference to be held at the Statler-Hilton Hotel, Hartford, Conn. Additional information can be obtained from Mr. William P. Carpenter, Superior Electric Co., 83 Laurel St., Bristol, Conn.

Oct. 13-15—

National Electronics Conference to be held at the Hotel Sherman, Chicago. Sponsors are American Institute of Electrical Engineers, Institute of Radio Engineers, and Illinois and Northwestern Universities. Additional information can be obtained from Rudolph E. Hornacek, Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.

Oct. 16-17—

National Conference on Industrial Hydraulics to be held at the Hotel Sherman, Chicago. Further information can be obtained from Raymond D. Meade, Director of Extension and Co-operative Education, Illinois Institute of Technology, 3300 S. Federal St., Chicago 16, Ill.

Oct. 16-18—

Foundry Equipment Manufacturers Association. Annual Meeting to be held at The Greenbrier, White

Sulphur Springs, W. Va. Additional information is available from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 20-22—

Society of Automotive Engineers Inc. National Transportation Meeting to be held at Lord Baltimore Hotel, Baltimore. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 22-24—

Society of Automotive Engineers Inc. National Diesel Engine Meeting to be held at Lord Baltimore Hotel, Baltimore. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 23-25—

National Society of Professional Engineers. Fall Meeting to be held at St. Francis Hotel, San Francisco. Further information is available from NSPE headquarters, 2029 K. St. N.W., Washington 6, D. C.

Oct. 27-31—

American Society for Metals. National Metal Exposition and Congress to be held at the Public Auditorium, Cleveland. Additional information can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

Oct. 28—

Ultrasonic Manufacturers Association. Annual Meeting to be held

"Still stuck for ideas?"

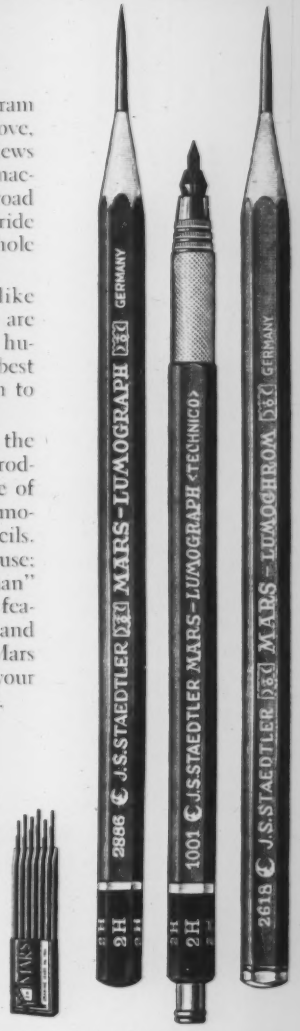
MARS outstanding design **SERIES**

roll your own!

Speeding up our national road-building program is the goal of this design by Russ Henke of Elm Grove, Wisconsin. His behemoth of a machine literally chews up unmapped earth, compacts it with asphalt or macadam, stabilizes it, and lays a ribbon of paved road behind as it rumbles along! Crew and engineers ride in an air-conditioned cabin, and monitor the whole process by control instrumentation.

Tomorrow's roads may be squeezed out like toothpaste, but outstanding ideas for tomorrow are still produced in the old-fashioned, painstaking, human way. And only professionals know how the best in drafting tools can smooth the way from dream to practical project.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom color-drafting pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

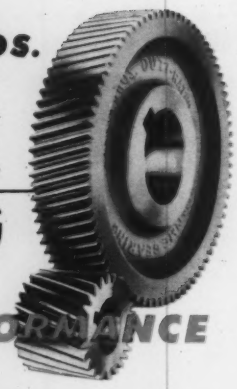
at all good engineering and drawing material suppliers

Circle 425 on Page 19

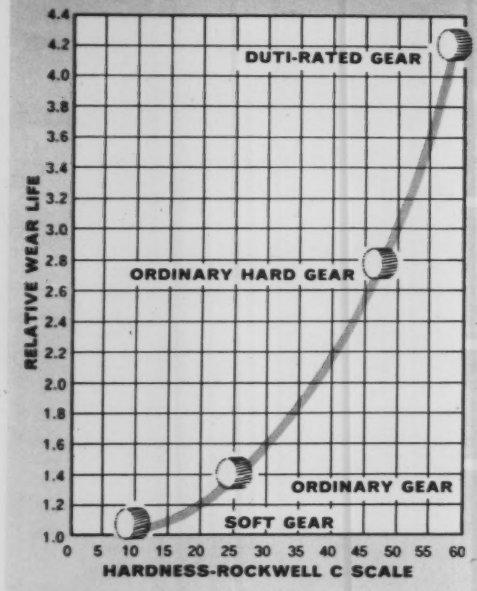
HERE'S WHY FOOTE BROS.

Duti-Rated
LIFETIME GEARING

GIVES BETTER PERFORMANCE
...LONGER LIFE



GEAR PERFORMANCE COMPARISON CHART



DUTI-RATED GEAR—
Hardened after cutting. Precision processing permits maximum hardness while holding accuracy within extremely close tolerances.

ORDINARY HARD GEAR—
Hardened after hobbing and shaving; hardness limited to maintain reasonable accuracy.

ORDINARY GEAR—
Hardened before cutting; hardening limited to maintain machinability.

SOFT GEAR—
Low hardness—excessive size required because of low capacity.

LINE-O-POWER Speed Reducer

AND YOU GET
Duti-Rated
Gearing in EVERY
Line-O-Power Drive

LINE-O-POWER Right Angle Drive

Horizontal GEARMOTOR Speed Reducer

Horizontal VARI-MOUNT Variable Speed Drive

Vertical LINE-O-MOUNT Speed Reducer

Write for DUTI-RATED Gear and LINE-O-POWER Catalogs.
See how you can get more for your drive dollar.

this trademark stands for the finest industrial gearing made

T. M. REG. U. S. PAT. OFF.

FOOTE BROS.
Better Power Transmission Through Better Gears
FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Boulevard · Chicago 9, Illinois

at the Hotel Cleveland, Cleveland. Additional information can be obtained from association headquarters, 271 North Ave., New Rochelle, N. Y.

Oct. 29-30—

Computer Applications Symposium to be held at the Morrison Hotel, Chicago. Sponsor is the Armour Research Foundation of Illinois Institute of Technology. Further information can be obtained from Dr. Frederick Bock, Electrical Engineering Research Dept., ARF, 10 W. 35th St., Chicago 16, Ill.

Nov. 5-6—

Society of Automotive Engineers Inc. National Fuels and Lubricants Meeting to be held at The Mayo, Tulsa, Okla. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 10-12—

Steel Founders' Society of America. Thirteenth Technical and Operating Conference to be held at the Pick-Carter Hotel, Cleveland. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Nov. 17-18—

Conference on Magnetism and Magnetic Materials to be held at the Sheraton Hotel, Philadelphia. Conference is sponsored by the American Institute of Electrical Engineers, in co-operation with the American Physical Society, the Institute of Radio Engineers, the Metallurgical Society of AIME, and the Office of Naval Research. Further information can be obtained from Mr. C. J. Kriessman, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia, Pa.

Nov. 17-21—

Society of the Plastics Industry Inc. National Plastics Exposition and Annual Conference to be held at the International Amphitheatre, Chicago. Further information can be obtained from society headquarters, 250 Park Ave., New York 17, N. Y.

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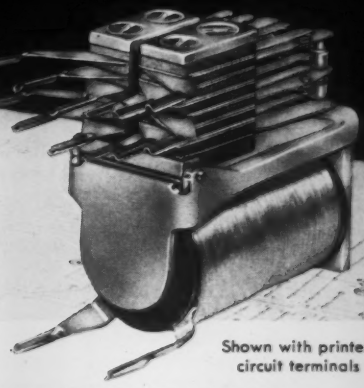
Circle 427 on Page 19→

HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW



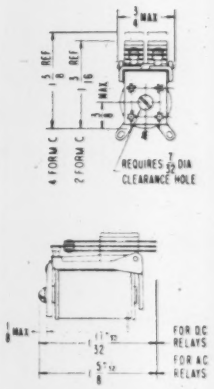
Shown with printed circuit terminals

VERSATILITY

and adaptability are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required...when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.



ENGINEERING DATA/MH RELAY

Insulation: Laminated phenolic.

Insulation Resistance: 100 megohms minimum.

Breakdown Voltage: 500 volts RMS between all elements.

Shock: Up to 30g.

Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.

Ambient Temperature: —45°C. to +85°C. —(65°C. to +125°C. on special order).

Weight: 2½ oz. max. (open relay)

Pull-In: Approx. 75% of nominal voltage.

Pull-In Speed: Approx. 15 ms.

Drop-Out Speed: Approx. 10 ms.

Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:

Arrangements: Up to 9 springs per stack.

Material: ⅛" silver; also Palladium or gold alloy.

Load: Dry circuits to 5 amps @115V AC resistive.

COILS:

Resistance: 22,000 ohms max.

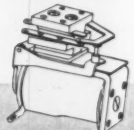
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)

Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)

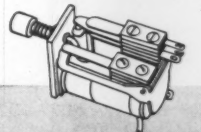
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.

Current: 2.5 ma to 10 amps DC.

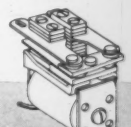
P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



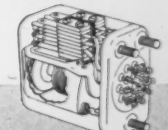
MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



MA LATCHING
Electrical latch; mechanical reset. Small, versatile and offered with selection of contact arrangements.



MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.



MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

Memo on Metals

New Age-hardenable Titanium Alloys Offer Up to 220,000 psi Tensile Strength and Easier Formability for 600 to 1,000 F Applications

Three new age-hardenable titanium alloys may prove to be the solution to many of the strength-weight and temperature problems encountered in designing advanced aircraft and missiles. They may also prove extremely economical for such applications.

All three offer much higher strengths than other titanium alloys – and have the light weight and corrosion resistance typical of titanium alloys. Furthermore, they are readily FORMAGEABLE* – capable of being formed in the solution-treated or "soft" condition and then strengthened by simple thermal aging techniques. Each is now in pilot production and available in limited quantities of mill products.

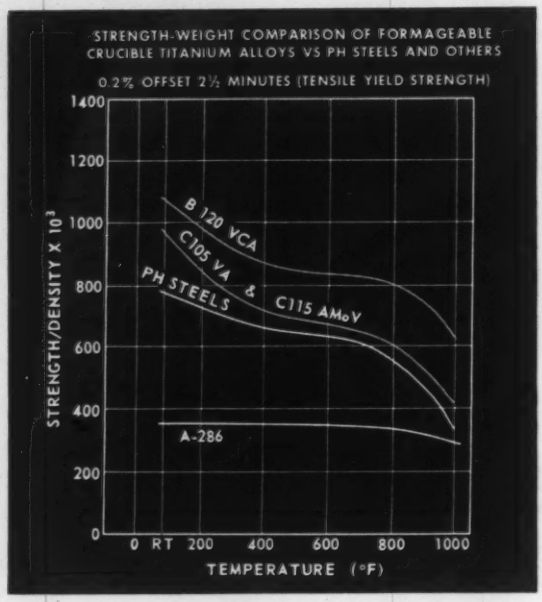
First Age-hardenable All-beta Ti Alloy

Crucible B-120VCA is the first useful titanium alloy with an all-beta (high temperature) structure. It has both the highest strength and best formability of any titanium-base alloy.

This alloy's composition (13%V-11%Cr-3%Al) enables its structure to stay all-beta during forming and/or during slow cooling, and to age to high strength levels at temperatures where distortion is not a problem.

B-120VCA has a unique combination of properties. Room temperature strengths of 200,000 to 250,000 psi have been obtained. On a strength-weight basis this is the highest strength of any available structural material. In short-time elevated temperature tensile tests (1-2 minutes), it offers a decided strength-weight advantage over alternate materials at temperatures up to at least 1,000 F. Under creep conditions, for very long periods of time, it enjoys a strength-weight advantage up to at least 600 F. Beyond this limit, the other Crucible FORMAGEABLE titanium alloys are recommended.

B-120VCA is ductile-weldable, cold-headable, and has great and deep hardenability. Because of this formability, it should prove suitable for applications such as aircraft skins, stiffeners and other primary structural shapes, and for missile pressure tanks, rocket motor cases and structural members. Preliminary tests indicate it may prove unequalled as a construction material for honeycomb assemblies. Because it is so easy to cold-head, it has a large potential in such items as rivets.



Alpha-beta Titanium-base Alloys

Crucible C-105VA is an alph-beta titanium-base material which also is FORMAGEABLE. Its 16% vanadium content stabilizes a sufficient amount of the beta phase for good age-hardenable response; the 2.5% Al content improves the alloy's elevated temperature properties.

C-105VA resolves two conflicting requirements for aircraft sheet material. It is soft, ductile and easily formed in the solution-quenched condition. Because the formed parts can be aged subsequently at moderate temperatures, parts made of C-105VA can possess high strengths at temperatures up to 800 F for long periods of time.

* *age-hardenable titanium alloys*
* *tool steels in production parts*
* *borated stainless steels*

This third alloy, C-115 AMoV (4%Al-3%Mo-1%V), also shows considerable promise for aircraft sheet applications. It is age-hardenable to higher strengths than C-105VA with only slight sacrifice in forming characteristics.

Considerable data on the properties and fabricating qualities of all three alloys have been assembled by Crucible's Titanium Division. For data sheets and additional information, send the coupon.

Tool Steels Replace Standard Alloys for Production Parts

As design and metallurgical engineers require materials with improved properties or greater uniformity, they are turning more to the use of tool steel for production parts. Here are three good examples:

1. Vanes in the hydraulic system that actuates the automatic steering mechanism on cars are made of Crucible REX® M-2 high speed steel. REX M-2 combines the abrasion resistance necessary for minimum wear with the impact resistance needed for long life and safety. The manufacturer experimented with numerous other steels, but high speed steel lasted longer than any other type tested.

2. Actuator bars for a nationally-known calculator are now being produced of Crucible KETOS® – a low-priced AISI Type O1 alloy tool steel – because the thin, close-tolerance contact edges withstood over 4-million high speed blows in a life test. No other steel has lasted more than 1-million cycles before chipping and failing.

3. Cylinder block for a fast acting, aircraft hydraulic pump made of Crucible Chrome tool steel. Pump operates at temperatures up to 500 F, pressures to 5,000 psi. Tool steel was selected over a standard AISI alloy because of its high degree of cleanliness, uniform response to heat treatment, and controlled hardenability. Furthermore, because tool steel practices are employed in making it, the steel more consistently meets the critical mechanical and physical properties required in this application.

For data sheets on these and all other Crucible tool steels – send the coupon.

High Boron Stainless Steels Made Possible by Vacuum Melting

Type 304 stainless steel with boron has proved to be an excellent material for nuclear equipment, because the boron readily absorbs neutrons. By increasing the boron content, valuable weight and thickness reductions can be made in reactor shielding and control rods.

Unfortunately, conventionally melted borated 304 becomes "hot short" – virtually impossible to work if the boron content exceeds 1%. Vacuum melting has provided the answer to this problem. Vacuum-melted 304 stainless is readily workable when the boron content goes up to 2% or even higher.

Vacuum melting the alloy also provides closer control of the composition, because only pure materials are used. So, undesirable elements such as cobalt – which becomes radioactive upon bombardment – can be kept to a minimum. In fact, vacuum-melted Type 304 stainless can be supplied with less than .001% cobalt.

For additional information on vacuum-melted steels – send the coupon.

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. E107, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:
Please send me the following:
1. Data sheets on B-120VCA ☐ C-105VA ☐ C-115AMoV ☐
2. A copy of "Titanium Alloys for Aircraft and Spacecraft" by Finlay, Vordahl and Malone ☐
3. Data Book on Crucible tool steels ☐
4. Data sheets on vacuum-melted steels ☐

Name_____ Title_____
Company_____
Street_____
City_____ Zone_____ State_____

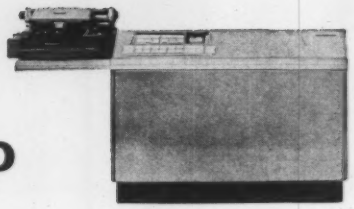
CRUCIBLE STEEL COMPANY OF AMERICA

*Reg. Trade Mark

Circle 429 on Page 19

TODAY'S GREATEST VALUE IN ELECTRONIC COMPUTERS!

ROYAL PRECISION LGP-30



Compare it, feature by feature, with the other computers in its class

Feature	Computer A	Computer B	Computer C	Computer D	LGP-30	
Memory Size	220 words for data only	2160 words	1000 or 2000 words	84 words for data only	4096 words for data & program (either or both)	LARGEST CAPACITY IN ITS CLASS
Max. Speed Add Multiply	 20/sec. 4/sec.	 Comparable to LGP-30	 Comparable to LGP-30	 3/sec. 1/sec.	 Over 440/sec. Over 50/sec.	SPEED EQUAL TO MANY ROOM-SIZED COMPUTERS
Size	17 sq. ft.	6.5 sq. ft. plus table for typewriter.	45 sq. ft.	9.2 sq. ft. plus table for typewriter & control unit.	11 sq. ft.	COMPACT, DESK-SIZED, COMPLETELY MOBILE
Input-Output	Keyboard only — tape at extra cost.	Independent tape preparation at extra cost.	Extra cost peripheral equipment required.	Tape and typewriter for numerical input-output only. Independent tape preparation at extra cost.	Tape typewriter for alpha-numeric input-output standard equipment.	DELIVERED COMPLETE. NO ADDITIONAL EQUIPMENT NEEDED TO PREPARE DATA, PROGRAM OR REPORTS
No. of tubes	165	450	2,000	248	113	FEWER COMPONENTS MEAN LESS MAINTENANCE, FEWER CHECKOUTS
Voltage	220 V	110 V	220 V	110 V	110V	PLUGS INTO ANY REGULAR WALL OUTLET
Power	2.5 KW	3.0 KW	17.7 KW	1.65 KW	1.5 KW	NO SPECIAL WIRING OR AIR-CONDITIONING REQUIRED
Ease of programming & operation	Not alpha-numeric. No internal program storage.	Alpha-numeric at extra cost. 8 part instruction. Requires computer specialist.	Alpha-numeric at extra cost. Requires computer specialist.	Not alpha-numeric. No internal program storage.	Alpha-numeric. Complete internal program storage. Standard typewriter keyboard. Simplest command structure of all.	EASY TO PROGRAM AND OPERATE.
Cost Sale Rental	 $38,000 $1000/mo.	 $49,500 $1485/mo.	 $205,900 $3750/mo. up	 $55,000 $1150/mo.	 $49,500 $1100/mo.	LOWEST COST EVER FOR A COMPLETE GENERAL PURPOSE COMPUTER

Nation-wide sales and service. Trained staff of applications analysts. Library of subroutines available, plus programs for wide variety of applications.

For further information and specifications on Royal Precision LGP-30, call your nearby Royal McBee office, or write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.

ROYAL McBEE

WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS AND MAKERS OF DATA PROCESSING EQUIPMENT

Circle 430 on Page 19

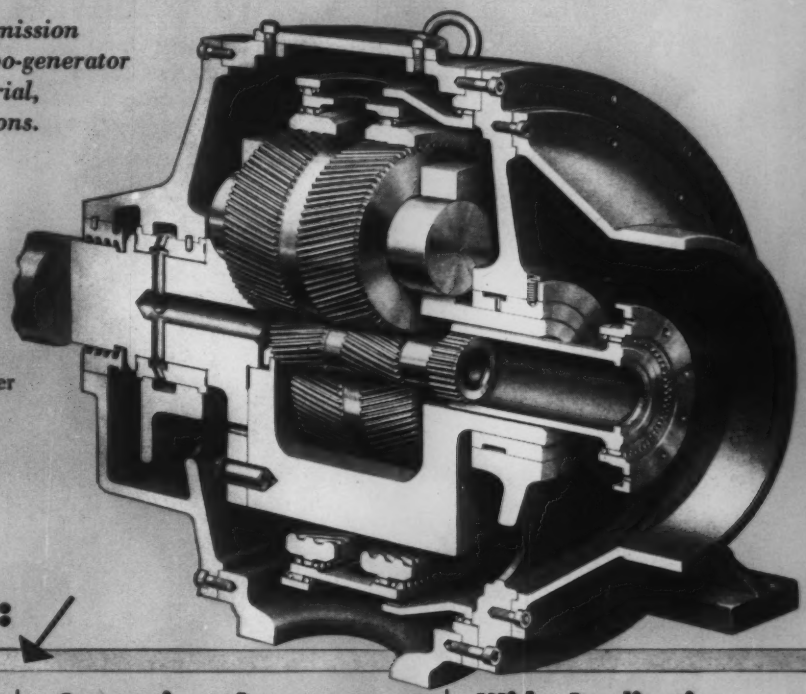
DE LAVAL-STOECKICHT
PLANETARY GEAR

...for high speeds...high horsepower

Proved in hundreds of installations abroad totalling over 3,000,000 horsepower—now available in America!

For all high torque power transmission applications such as pump turbo-generator and compressor drives in industrial, municipal and marine installations.

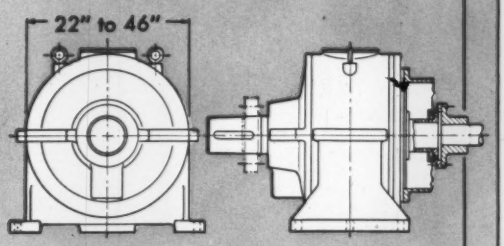
This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)...no high speed bearings...less friction losses.



Check These Advantages:

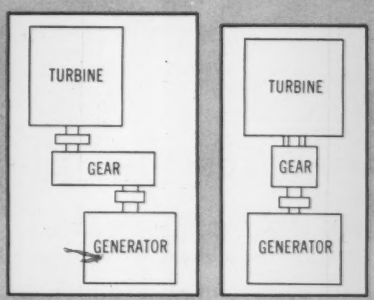
Small Size—Light Weight

Compact—low weight per hp. Sizes range from 22" to 46" in diameter, depending on horsepower requirements. Example: 5000 hp planetary unit weighs 1700 lbs. against 6000 lbs. for conventional gear.



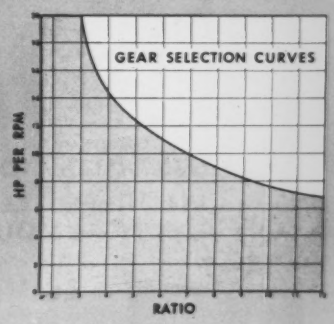
Convenient Arrangement

Co-axial or "in-line" arrangement of gear members takes up far less space than parallel axis gears of equivalent horsepower rating.



Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.



For further details, write for Bulletin 2400.

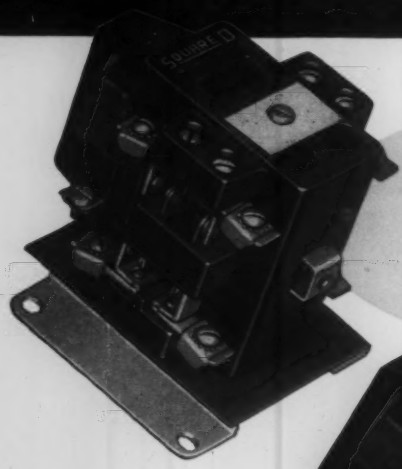
DE LAVAL *Steam Turbine Company*

Nottingham Way, Trenton 2, New Jersey

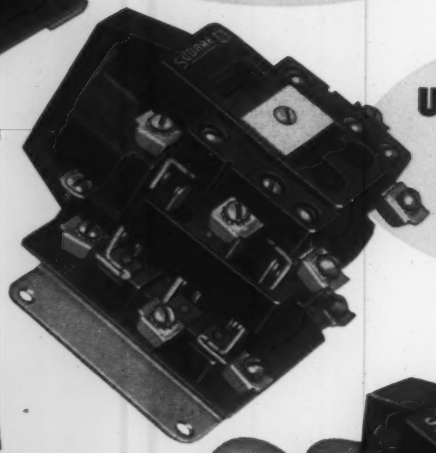
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

DL491

A COMPLETE LINE OF



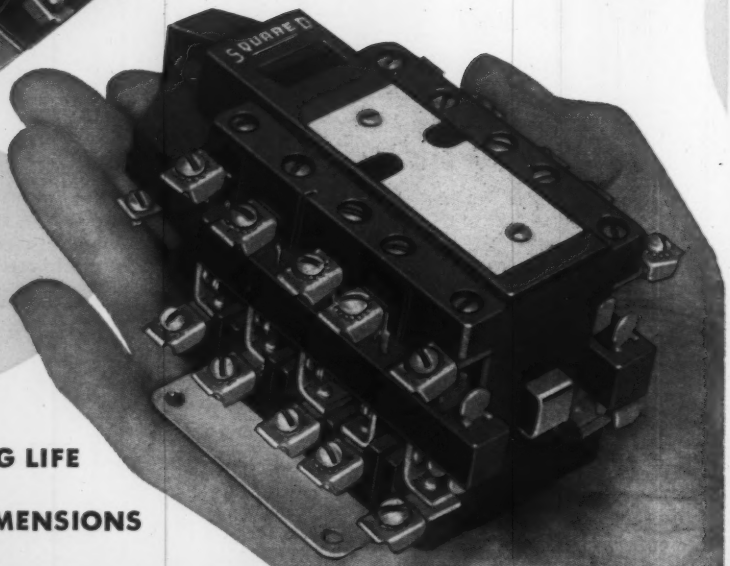
UP TO 4 CONTACTS
2 Normally Open
2 Normally Closed
Measures only
3-5/16" high x 2-5/8" wide!



UP TO 6 CONTACTS
4 Normally Open
2 Normally Closed
Measures only
3-11/16" high x 2-13/16" wide!

NEW!

UP TO 10 CONTACTS
Either 6 Normally Open and
4 Normally Closed or
8 Normally Open and
2 Normally Closed
Measures only
5" high x 3" wide!



- 600 VOLTS • 10 AMPERES • LONG LIFE
- ALL THREE SIZES HAVE IDENTICAL MOUNTING HOLE DIMENSIONS

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

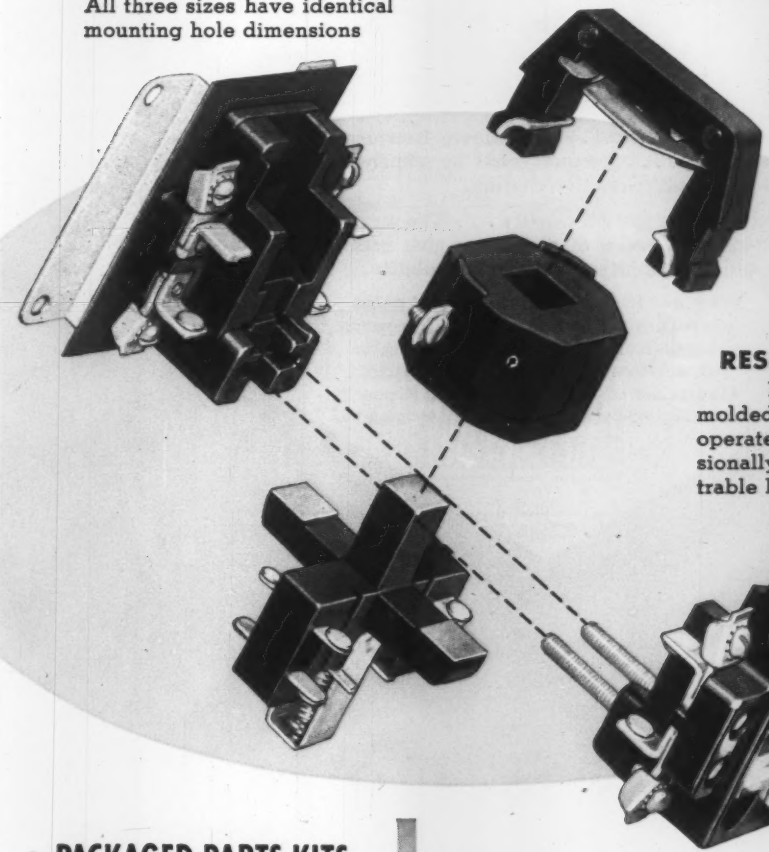
SQUARE D COMPANY

SPACE-SAVING RELAYS

Take Them Apart in 20 seconds...from the Front!
Not One Bit of Tear-Down Space Needed!

MOUNTING SIMPLIFIED
All three sizes have identical mounting hole dimensions

OUTSTANDING PERFORMANCE
Balanced construction reduces wear on single moving part...results in long life and safeguards against down-time



RESISTS DAMAGE
Plastic impregnated molded coil is unbreakable, operates cooler, is dimensionally stable and impenetrable by water and oil

20-SECOND DISASSEMBLY
Simply loosen two screws and the entire device is disassembled for normal maintenance

PACKAGED PARTS KITS
make normal maintenance easier than ever. Any way you look at it, these new relays are tops. Small in size—long on features and performance

for the Complete Story, write for Bulletin 8501-D
Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

Everybody's Ahead with Square D!

BEARINGS OF ALCOA ALUMINUM OUTPERFORM ALL OTHER SOLID-WALL BEARINGS...

Only aluminum has the combination of advantages demanded for the best all-around performance of solid-wall bearings. Alcoa® Aluminum alloys have the unmatched combination of these advantages to give you bearings that:

Withstand heaviest loads . . . Solid aluminum bearings withstand loads up to 10,000 psi on projected area.

Run cooler . . . Aluminum is the best heat conductor among bearing materials, and this means cooler running bearings . . . as much as 20° cooler by actual test.

Conform readily . . . Aluminum has good ductility, conforms readily to misaligned shafts or nonparallel pins and thus reduces unit loading for longer bearing life.

Have ideal embeddability . . . Aluminum embeds particles far better than bronze, but not as deeply as babbitt. Dirt particles roll out easily and are trapped by the filter.

Resist corrosion . . . Aluminum bearings do not corrode . . . are unaffected by additives in oils, need no protective coating.

Have design flexibility . . . The structural properties of aluminum give great design flexibility, ease of machinability.

Why not investigate the use of solid aluminum alloy bearings for your equipment? Call your nearest Alcoa sales office or write to Aluminum Company of America, 1986-J Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM BEARINGS

ALUMINUM COMPANY OF AMERICA

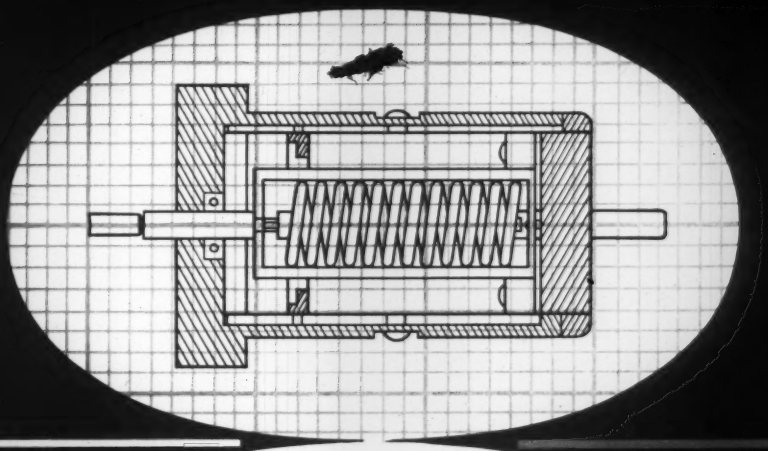
Your Guide to the Best in Aluminum Value

"ALCOA THEATRE"
Exciting Adventure,
Alternate Monday Evenings

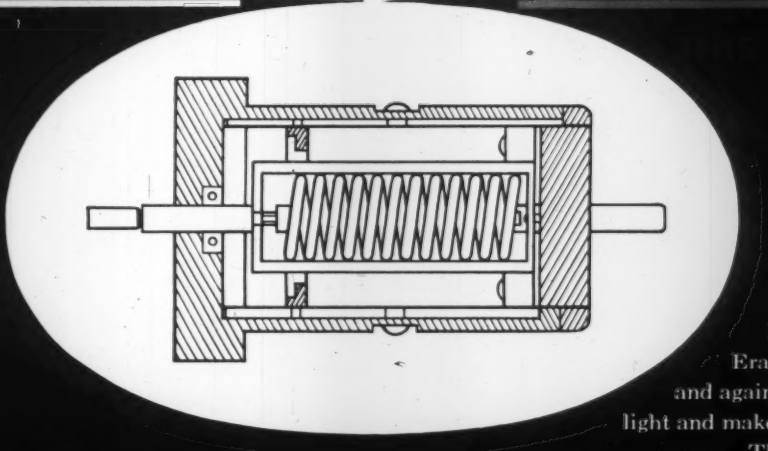
Circle 433 on Page 19

When you specify

Drafting costs are cut in half



Quickly and accurately rendered to scale with blue grid lines to guide you. Guide lines are on back of drawing surface enabling you to erase and erase without disturbing them.



Blue grid lines have disappeared completely giving sharp, easy-to-read copies.

Try Clearprint's perfect working surface with a 2H pencil – then with a pen. Lines are sharp and clear— Erase and draw the lines again and again. Now hold Clearprint to a light and make reproductions. No ghosts! Then test your present sheet.

Ask our representative or write us regarding Clearprint's revolutionary new "Pre-Print" which pre-prints your basic standards, typical details, title blocks, and bills of material. Their application to your particular needs can save thousands of dollars in drafting and lettering time!

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"PRE-PRINT" PAPER
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Clearprint is Watermarked For Your Protection

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1482 - 67th Street, Emeryville, Calif.

☐ Please send me sample Clearprint "Fade-Out" sheets, with prices.
☐ Send me Clearprint samples, with prices, for the following uses:

☐ Have your representative call at my office to discuss special applications for my particular needs.

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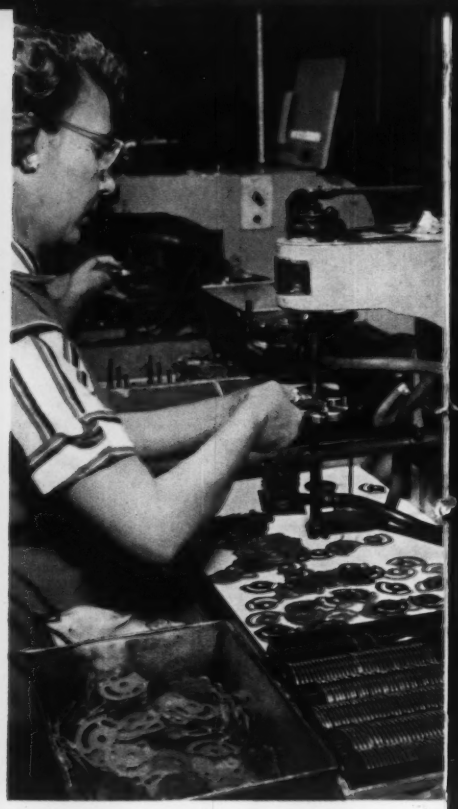
10

Circle 434 on Page 19

Circle 431 on Page 19→

Copper-Coated Strip, shown before heat-treat at Victor Adding Machine, prevents distortion of precision parts during case hardening of working surfaces.



Plain Steel number dials are welded to precision-made Thomas Strip.

Victor Adding Machine, Others Cut Costs, Improve Products With Thomas Strip

Manufacturers across the country are reporting new cost-cutting, quality-boosting results from their use of Thomas Strip's cold-rolled specialty steels.

At Victor Adding Machine Company, Chicago, for example, copper-coated Thomas Strip slashed one major production cost by 50% and made big savings in another operation.

Fred E. Rolli, Victor's chief engineer, says Thomas Strip is "the greatest single improvement in our production process in the past 10 years."

Here's why:

Victor's deluxe Model 75 contains 2500 individual parts, 68 of the most critical being made from Thomas Strip, both plain and copper-coated.

• **Distortion-Free.** Load-bearing parts—with tolerances under .001 inch, plus or minus, have to be case hardened along their sheared edges. Heat-treating plain steel (15 minutes at 1450 degrees) can warp the stamping. Often the expensive straightening process caused tiny surface cracks which elongated the part past the .001-inch tolerance.

To solve this problem, Victor turned to copper-coated Thomas Strip. Since the electrolytic layer of copper stops off or blocks carburizing gases, flat surfaces of the stamped part are protected. Then, plain steel edges case harden properly. The part retains flatness and proper ductility. Since there is no distortion, piece straightening of copper-coated parts is eliminated. This accounts for the 50% reduction of the total straightening operation at Victor.

• **More Savings.** A second economy begins in the punch press. Die-life is a vital factor of production costs. Like other users of copper-coated Thomas Strip, Victor finds die-life between grindings is extended as much as 33%. This is due to the lubrication effect of the copper coating.

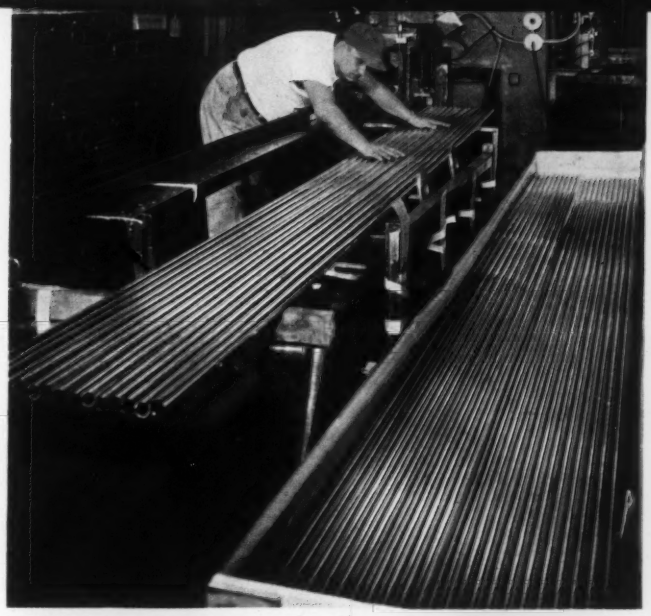
A third benefit: uniform temper and on-spec composition of Thomas Strip mean clean, burr-free sheared edges. Burrs, like slivers, are banes of close-tolerance operation of machine parts.

• **Satisfied.** Engineer Rolli sums it up by saying:

"Elimination of straightening is one of the biggest boons to small parts manufacturers that I've seen in the business. Even if Thomas Strip had no other benefits than eliminating a production problem, using copper-coated strip would be entirely worthwhile."

Thomas Strip's advantages are the same throughout industry. Other examples of how manufacturers cut costs, improve products—get higher profits and increase sales are shown here.

Thomas Strip's newly expanded and diversified production facilities give you the full range of products on these pages, in addition to zinc and chrome coatings . . . or hot-dip coated with lead alloy or tin. Uncoated Thomas Strip products include low carbon, alloy and high carbon spring steel grades.



Steel's Strength, Brass' Beauty are combined economically to form lock-joint tubing at Van Huffel Tube Corp., Warren, Ohio. Largest producer of rolled shapes in the nation, Van Huffel uses clear-lacquered, brass-coated Thomas Strip to make tubing for variety of products, including curtain rods and lamps. Thomas' brass and lacquer coatings easily withstand forming pressures and resist roll damage to the finish. Tubes usually need no further surface finishing. Van Huffel has been a satisfied Thomas Strip user for 26 years.

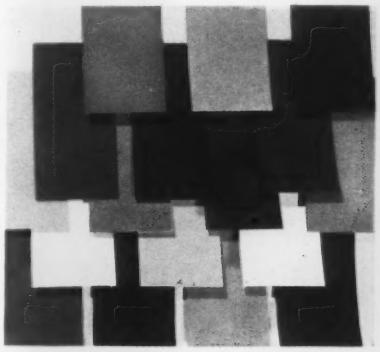
Capacity Up 25%, Sales Up 45% since Automatic Wire Goods Manufacturing Co., Bronx, New York, started using Thomas' nickel-plated strip 5 years ago. President Irving Spiegel says Thomas Strip boosted quality, kept production costs constant, improved appearance and design of his extensive Jewel and Automatic kitchen utensil lines. Thomas nickel-coated strip assures a mirror-like finish, an important feature of sales appeal in the highly competitive utensil field.

All Thomas Strip products can save you money and enhance your product in six important ways:

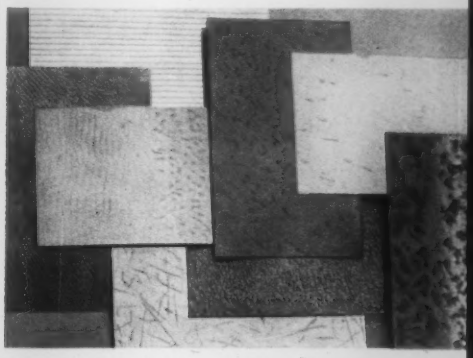
- **Fabricates Easily.** Coated steels stand fully as much fabrication as uncoated strip.
- **Longer Die Life.** Most coatings lubricate dies, reduce wear and increase tool life.
- **Maximum Pieces Per Pound.** Precision rolling to extremely close size tolerances gives more square feet of strip per ton.
- **Lower Plating Costs.** Coatings serve as final product finish or as base for further plating or painting.
- **Speeds Fabrication.** Thomas Strip coatings eliminate costly intermediate fabricating steps such as cleaning, buffing, even plating.
- **Steel's Strength and Economy** are combined with beauty and utility of more expensive metals.

All the savings and benefits Thomas Strip specialties are giving to fabricators shown here are available to you. A national sales staff—familiar with design and fabrication advantages of Thomas Strip is ready to serve you.

Write for samples, and additional cases of users' actual experiences with Thomas Strip products. Do it today!



The Rainbow's Range of colors, lacquered or painted on precision cold-rolled strip will solve your decorative and design problems. Thomas Strip's new lacquer line is the industry's finest. It's capable of wider widths in a fuller range of colors, especially pastel shades. Besides appearance, lacquer-coated steel is rugged and can be readily formed or mildly drawn without damage to the product's finish.



Unlimited Design opportunities come with pattern-rolled strip. New facilities enable Thomas to offer wider widths of any design and coating, including clear or colored lacquer. Users agree pattern-design enhances product sales appeal, permits production economies by eliminating piece buffing and costly further finishes. Pattern-designs stand up under tough forming operations and still offer attractive, flaw-free surfaces.

Thomas Strip® Division

Pittsburgh Steel Company

Grant Building · Pittsburgh 30, Pennsylvania

District Sales Offices:
Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

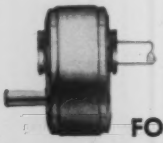
DETACHABLE MOTOR DESIGN
permits motor change in minutes
— avoids downtime for motor repairs.

Now - a MOTORIZED SPEED REDUCER FOR MOUNTING DIRECTLY ON SHAFT

the NEW BOSTON Gear® OPTIMOUNT TRADEMARK

IT'S THE NEW OPTIMOUNT

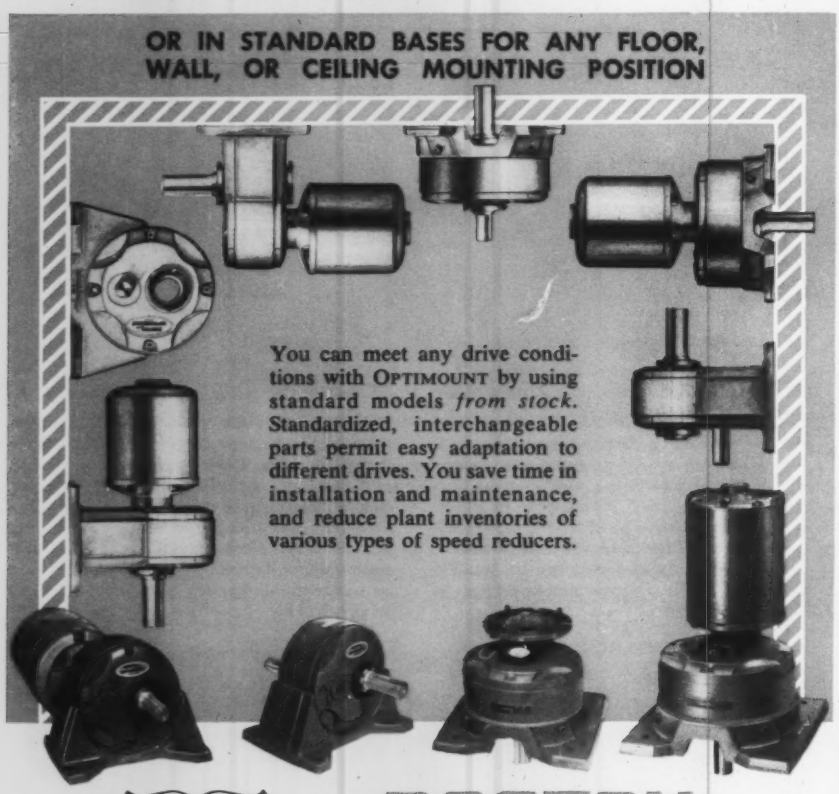
Ratiomotor for shaft mounting. It's the compact power package you have needed to save space without sacrifice of top transmission efficiency. Single or double reduction helical geared units deliver 87.4 to 431 output RPM. Get details—find out how OPTIMOUNT can solve your drive design problems.



HELICAL GEARED
REDUCTORS • RATIOMOTORS
AND FLANGED REDUCTORS

FOR SHAFT-MOUNTING . . .

OR IN STANDARD BASES FOR ANY FLOOR, WALL, OR CEILING MOUNTING POSITION



You can meet any drive conditions with OPTIMOUNT by using standard models *from stock*. Standardized, interchangeable parts permit easy adaptation to different drives. You save time in installation and maintenance, and reduce plant inventories of various types of speed reducers.

OPTIMOUNT delivers maximum power, with highest efficiency, through precision-finished helical gearing made to BOSTON Gear quality standards. Get details from your Distributor. He will demonstrate the many features that assure OPTIMUM PERFORMANCE. Boston Gear Works, 64 Hayward St., Quincy 71, Mass.

66 MODELS
FROM STOCK

680 OPTIONAL MOUNTING ARRANGEMENTS

1/6 to 15 H.P. DRIVES

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

INDUSTRIAL DISTRIBUTORS THE FIRST BAND OF PRODUCTION

CALL YOUR DISTRIBUTOR

BOSTON Gear

Remember — STANDARDIZATION PAYS —®

NEW CATALOG OP-1 lists complete OPTIMOUNT data—selection charts, application information.

Circle 435 on Page 19

DESIGN FREEDOM STARTS WITH ALCOA ALUMINUM

Alcoa Offers Screw Stock In Specific 12-ft. Lengths, No Increased Cost
PITTSBURGH, Aug. 30, 1958—Aluminum
Alcoa Adds Alloys 2024-T4, 6061-T6 to Screw Stock Schedule
PITTSBURGH, Nov. 11, 1957—Aluminum Company of America
Alcoa Extends Range Of Chamfered Ends At No Extra Cost
PITTSBURGH, Jan. 21, 1957—Aluminum Company of America today increased
Alcoa Stress Relieves Screw Machine Stock
PITTSBURGH, July 8, 1957—Stress-relieved
Alcoa Backs Distributor Stock With Mill Inventory
PITTSBURGH, March 18, 1957—Alu
Alcoa Buys Turnings And Borings
PITTSBURGH, April 1, 1958—Alumi
ALCOA
ALUMINUM
ALUMINUM COMPANY OF AMERICA
"ALCOA THEATRE"
Exciting Adventure
ALTERNATE MONDAY EVENINGS

THE BIG NEWS IN SCREW MACHINE STOCK COMES FROM ALCOA

We think there's more to service than making the best screw machine stock readily available in any quantity. ALCOA is consistently a step ahead with new economies, new design and production conveniences. Here are six ALCOA "firsts":

- Specific 12-ft lengths at no extra cost—all screw stock in rounds to 2⅞ in. dia. and hexagons to 2 in. across flats.
- Alloys 2024-T4 and 6061-T6 added to Screw Stock schedule. This means important economies through the addition of sizes formerly nonstandard which are now standard and groupable for price advantage.
- Chamfered ends at no extra cost for all rounds and hexagons up to 3 in. in alloys 2011-T3, -T8, 2017-T4, 2024-T4, 6061-T6.
- Full screw stock size range of alloys 2017-T4, 2024-T4, 6061-T6 stress relieved for improved machining characteristics.
- Mill inventory to supplement distributor stock and cover emergency requirements of mill customers.
- ALCOA agrees to purchase up to 60 per cent of customer's turnings and borings generated from alloys 2011-T3, 2017-T4, 2024-T4 and 6061-T6.

These and other reasons have prompted designers and production engineers of leading industries to switch to ALCOA® Aluminum Screw Machine Stock. The whole story, with direct quotes, is in three new ALCOA booklets—yours for the asking. Use the coupon.

Aluminum Company of America
873-J Alcoa Building, Pittsburgh 19, Pa.

Please send your case-history booklets containing quotes from leaders in industry on why they buy from Alcoa.

Name_____

Position_____

Company_____

Address_____

City_____ Zone____ State_____

Manufacturer cuts product cost

Problem: A Spokane, Washington manufacturer sold band-mill saws to the lumber industry. Soaring expenses were pushing unit costs out of sight. To remain competitive, he had to sell his product for less. He called in his local Century Electric sales engineer for help.

Solution: The Century Electric sales engineer studied the motor drive for the unit. He proposed a new gearmotor drive to replace the cumbersome mechanical transmission system. The compact Century Electric gearmotor required less space and was easier to install and maintain. Fewer parts were required—assembly was simplified. Savings in manufacturing costs: $192. The manufacturer was well on his way to solving his cost problem.

$192 with Century Electric motor

More than a motor: This is another example of why you get more than a motor when you take your motor problems to Century Electric. You will have the help of experts who think, sell and apply motors—and nothing *but* motors—day after day. They may be able to show you how to get better performance and cut costs for your product.

For more information, contact your nearest Century Electric Sales Office or Authorized Distributor.

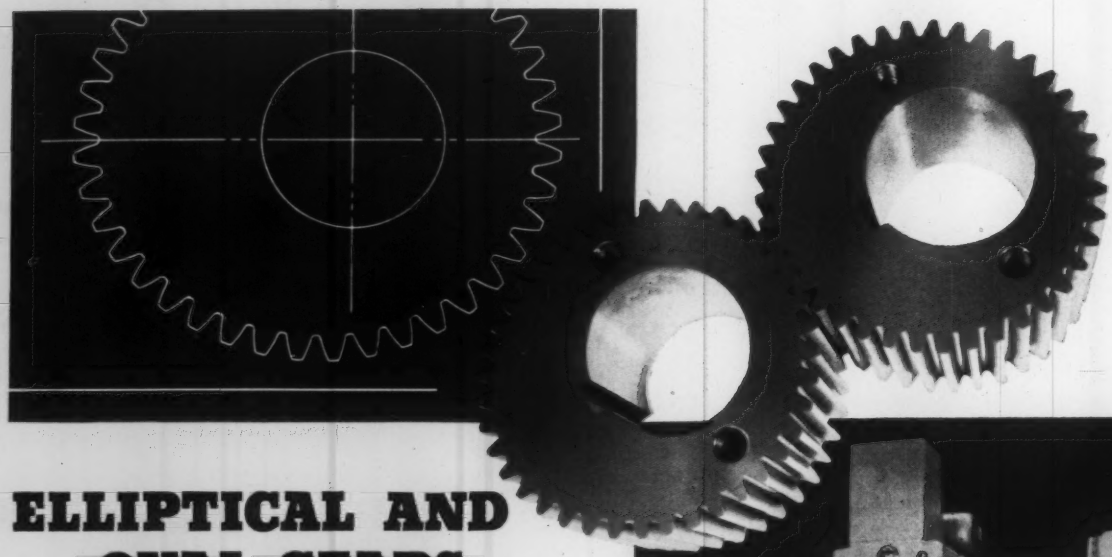
CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

58-2

Circle 437 on Page 19

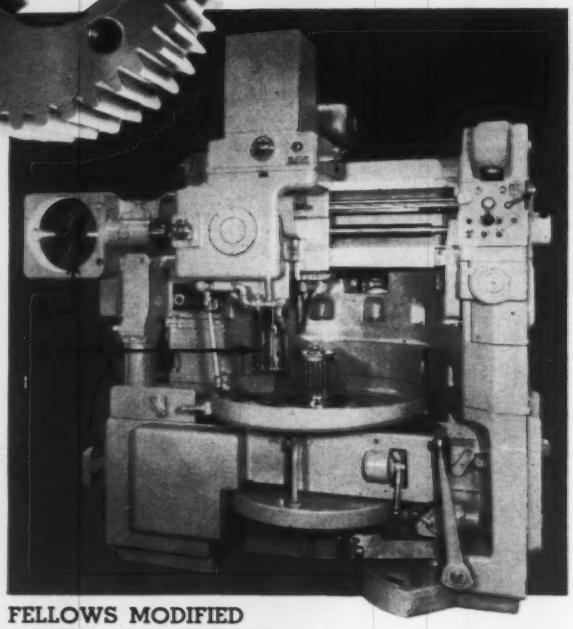


ELLIPTICAL AND OVAL GEARS

produced accurately and economically

Until now, owing to production difficulties, the design advantages of oval or elliptical gears have rarely been realized. Now Fellows has developed a unique method of generating these gears rapidly and economically. This new method minimizes the difficulty of wide variations in backlash experienced with such gears cut by previous methods. Full or modified involute teeth are produced to a higher degree of accuracy than was ever possible before on gears of this type. Production in any quantity is as simple as in cutting conventional cylindrical gears, once the setup has been made.

Fellows Modified 36-Type Gear Shaper generates elliptical or oval gears by continuously varying the center distance between cutter and gear during the cutting operation. A contour cam (A) and follower move the saddle the required amount in timed relationship with the rotation of the eccentric cutter-spindle adapter (B) to produce the gear pitch line contour.



FELLOWS MODIFIED 36-TYPE GEAR SHAPER

In addition to *oval and elliptical gears* up to a maximum pitch diameter of 18", the Modified Fellows 36-Type Gear Shaper can produce a remarkable variety of *irregular contours* at high production rates. Two cams, a cutter-spindle adapter and a cutter are required for each gear or other shape specification. For further information, get in touch with any Fellows office.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE Fellows *Gear Production Equipment*

Circle 438 on Page 19

How neoprene makes improved air valve design practical

A simple helical spring, covered with neoprene tubing, replaced a complicated metal sleeve valve in a ventilation unit made by Connor Engineering Corporation. It governs the flow of air into the mixing chamber of Connor's air diffuser.

One end of the spring fits into the air duct and the other end is capped. The capped end is mechanically linked to air temperature and volume controls. Air flows through the extended spring; when the control mechanism compresses the spring, air flow is throttled or shut off.

Many resilient materials might have been used for this novel valve — but with Du Pont neoprene, the designers expect the tubing to last as long as the ventilating system. Neoprene's excellent aging properties mean that the tubing will remain resilient and assure a tight seal on close-off.

Neoprene's properties are stimulating other new design ideas. Resistance to oil, weather, heat, many chemicals and flex fatigue are important in many products.

For more information, send the coupon. We'll also be glad to tell you about two new Du Pont elastomers, HYPALON® and VITON.

ELASTOMERS IN ACTION HYPALON® • NEOPRENE VITON TRADEMARK

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont elastomers in industry).

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-9
Wilmington 98, Delaware

Name _____

Firm _____

Address _____

City _____ *State* _____

Circle 439 on Page 19

IT PAYS TO STANDARDIZE ON **STANSCREW**

Stanscrew service helps insure quality for new Tuthill pump

Marvin Williams, Works Manager, Tuthill Pump Company, says: "Dependable, precision-built fasteners are an essential ingredient of the quality we build into Tuthill Pumps.

"Therefore, when we designed our new series of high pressure Powermax pumps, we had our distributor arrange for a visit from Stanscrew's fastener specialist. The socket head cap screws he recommended for this demanding application met the stringent standards we have established. And because of our years of experience with Stanscrew, we know we can count on precise product uniformity and fast service."

Hundreds of other leading companies in American industry have also learned that it pays to standardize on Stanscrew. For Stanscrew offers a comprehensive line of over 4,000 different types and sizes of standard fasteners . . . including a complete selection of socket, set, and cap screws. These are produced in three modern plants by fastener specialists with over 85 years of specialized experience. All 4,000 items are always in stock . . . quickly available.

When you have a fastener problem, call your Stanscrew distributor. He will arrange for a prompt visit from the Stanscrew fastener specialist. The specific recommendations he will make can often mean important savings.

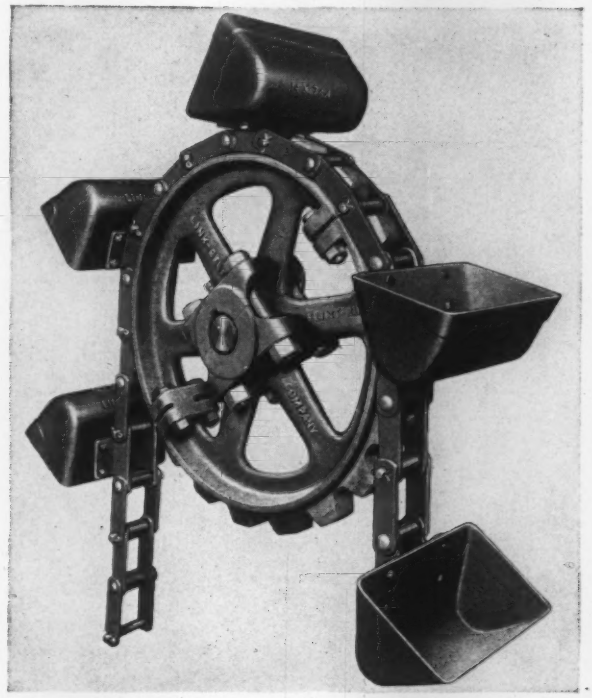
STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 440 on Page 19

Link-Belt SS Class bushed chain outlives previous chain 4 times



LONG, TROUBLE-FREE SERVICE of SS-111 chain (above) proves that it pays to select the right chain for a specific job from Link-Belt's complete line. It also proves that there's no need to pay a premium for costly special alloy steel chains.

Outstanding record established in severe, abrasive elevator service

This remarkable service record set by a Link-Belt SS-111 bushed chain (left) proves that often there's no need to go to excessively costly special alloy cast chains to get long life. Used at an Indianapolis (Ind.) fertilizer plant, this chain handled an average of 75,000 to 80,000 tons of fertilizer before requiring replacement. The previous type of chain handled only 18,000 tons and required four times as much maintenance.

Designed for abrasive jobs

Link-Belt SS-111 bushed chain offers large joint bearing surfaces for greater wear resistance and trouble-free service in heavy-duty conveying and elevating. Sidebars of selected bar steel are accurately formed and machined for tight press fit of pins and bushings. The latter are made from tough, hardened steel and locked against rotation in sidebars.

These straight steel sidebars with hardened steel pins and bushings provide needed strength to prevent distortion under continuous heavy loads. Smooth, tough surfaces repel gritty materials, prevent packing in critical joints, resist abrasion and corrosion.

Many sizes of these heavy-duty chains are interchangeable with Link-Belt combination chains. And a wide range of attachments makes them adaptable to specific conveying and elevating requirements.

18 million tons, 26 years later... SS-856 chain still serviceable

Sets record in cement mill elevator service

The more than quarter-century of continuous handling of raw materials at a Pennsylvania cement mill illustrates the long-wearing durability of Link-Belt SS-856 elevator chain. This amazing service record under extremely tough conditions proves that it pays to pick the right chain from Link-Belt's complete line.

Link-Belt SS-856 chain is made of high carbon steel sidebars with nickel alloy pins and bushings. Hardened sidebars give additional strength plus greater resistance to wear and pitch hole distortion. In addition, accurately machined pitch holes assure proper pitch and tight press fit of mating parts —extend chain life. The hard, smooth surfaces of steel joints repel gritty materials . . . resist abrasion.

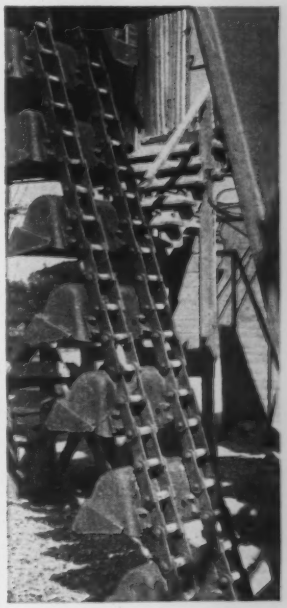
Link-Belt elevator chains are available with ultimate strengths up to 200,000 lbs.

Link-Belt SS-102½ bushed chain extends life of stone elevator

Several years ago an eastern stone quarry installed a main bucket elevator to handle 200 tons per hour of minus 2¼-in. mixed stone. Service life of the original two-strand elevator chain was found inadequate. After several shutdowns, it was replaced with Link-Belt SS-102½ chain with K-5 attachments at every third link.

This long-life, wear-resistant chain is now in its fourth year of uninterrupted operation. It has carried close to 350,000 tons as compared to 60,000 tons which was considered normal life for the previous chain.

Recent inspection of the SS-102½ chain reveals that it is good for another long stretch of service. Elimination of shutdowns and replacements more than justified the slight difference in cost between this and the original chain.



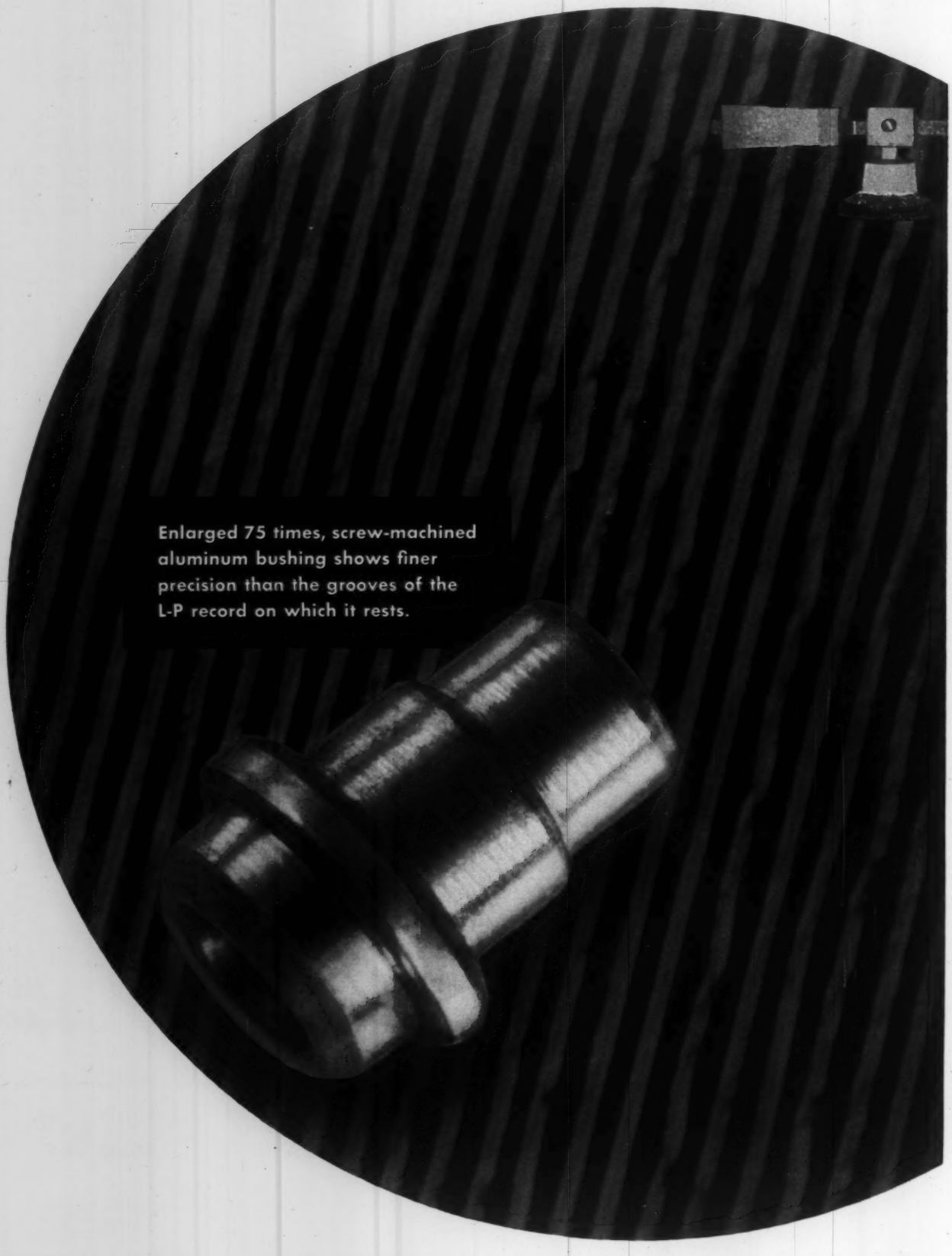
STONE ELEVATOR has buckets at every third link. Centers are 65 feet, with elevator inclined 75 degrees from the grade. Chain speed is 280 feet per minute.

HEADQUARTERS for chains, sprockets and other Link-Belt conveying and mechanical power transmission products is your nearby Link-Belt Office.

LINK-BELT

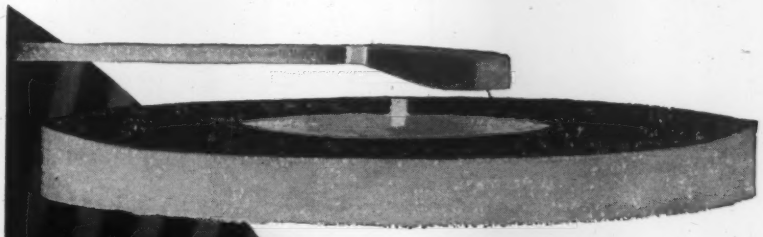
CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,294-A



Enlarged 75 times, screw-machined aluminum bushing shows finer precision than the grooves of the L-P record on which it rests.

What the designer conceives . . . aluminum achieves!



0.040-INCH DIAMETER ALUMINUM BUSHING TO HOLD L-P RECORD PLAYER NEEDLE

Designers: Fidelitone, Inc.; Jensen Industries
Screw Machine Operator: Walter Precision Company

The sensitive diamond or sapphire needle used in modern L-P record players must be held by a precision bushing that is soft, but at the same time very strong.

SOFT—to permit the needle to be inserted by gentle pressure.

STRONG—to hold the needle firmly in precise alignment through years of use. In addition, the holding piece must be non-magnetic and light weight.

To best fit these conditions of the bushing design, aluminum was selected. But because the smallest readily-available aluminum rod was ⅛-inch size, they still had the problem of grinding down to a center size of 0.045 before manufacturing the bushing.

Their solution? . . . call Kaiser Aluminum screw machine design and operator specialists. Kaiser Aluminum, besides drawing the rod to 0.045, also *straightened* the coiled aluminum into 10-foot rods.

This material was held to a plus or minus .0005 inch, making it possible to maintain concentricity and finish the part to these dimensions: Diameter 0.040; Overall Length 0.050 to 0.055; Inside Hole Diameters 0.0145 and 0.0165. The smallest O.D. is 0.027 to 0.028, making a wall thickness of only 0.0065.

The manufacturer now gets four times as many parts from the same amount of metal—about 36,000 parts per pound—at half the former cost!

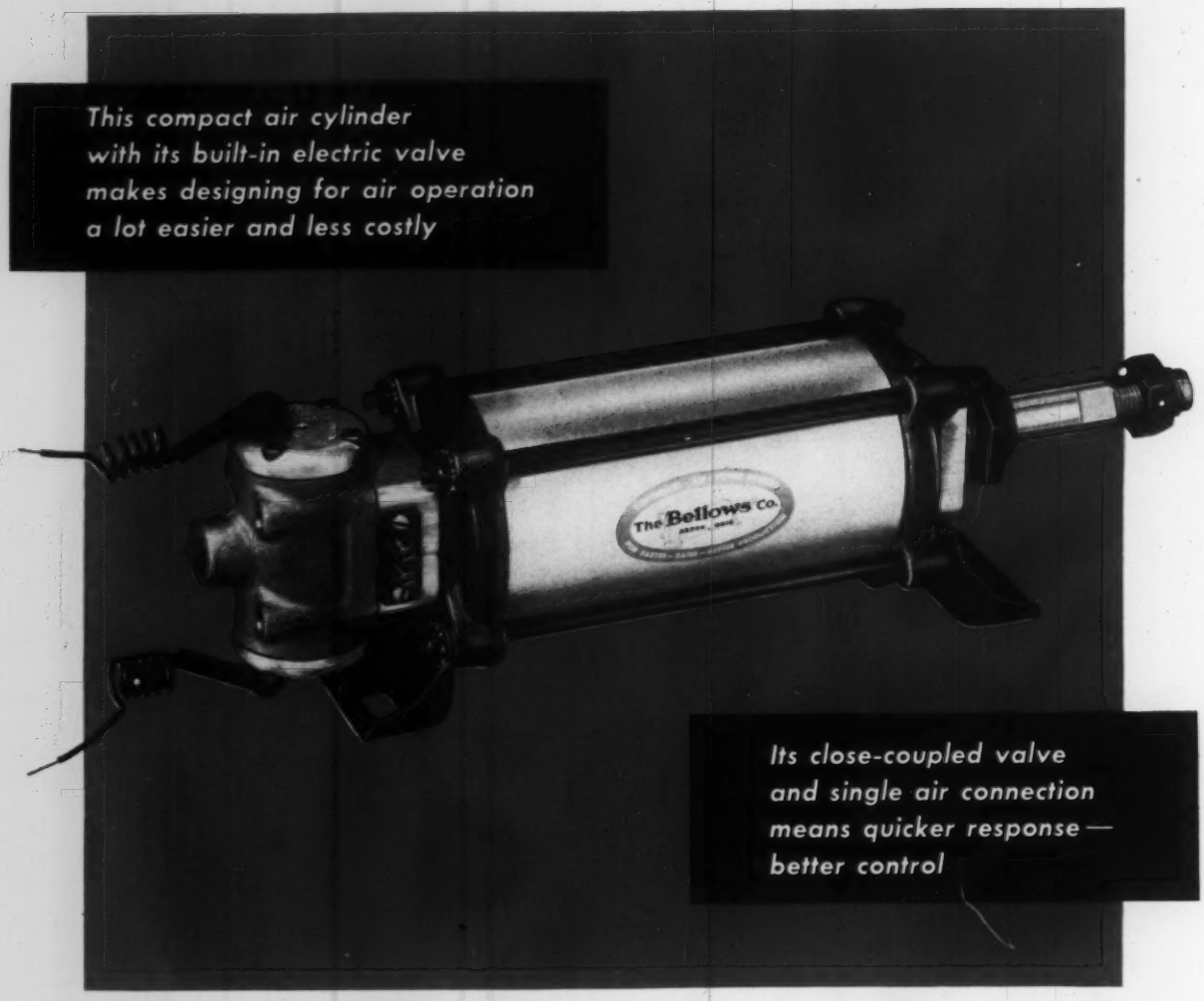
Kaiser Aluminum specialists are immediately available to offer design and production assistance for *any* screw machine problem that you may have. Call the Kaiser Aluminum sales office or distributor listed in your telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Ill.; *Executive Office*, Kaiser Bldg., Oakland 12, Calif.

FOR THE COMPETITIVE EDGE, GO ALUMINUM

KAISER ALUMINUM

SEE 'MAVERICK' • SUNDAY EVENINGS, ABC-TV NETWORK • CONSULT YOUR LOCAL TV LISTING


This compact air cylinder with its built-in electric valve makes designing for air operation a lot easier and less costly
The Bellows Co.
Its close-coupled valve and single air connection means quicker response—better control

ONE QUICK LOOK TELLS YOU WHY THE BELLOWS AIR MOTOR MEETS ORIGINAL EQUIPMENT DESIGN NEEDS SO PERFECTLY

As you can see, it takes but little more space, built-in valving and all, than a conventional air cylinder alone, without valve. Its single air connection (which can be inexpensive and easily installed flexible hose) makes it simple to install on moving machine elements. Its low voltage (8-12 v.) electrically controlled valve* permits less costly wiring, simpler hook-up, and easy interlock with related movements.

1013-B

The Place of the Bellows Air Motor in Original Equipment Design is the subject of a 16-page bulletin. We'll be happy to send you a copy without cost or obligation. Write Dept. MD-958, The Bellows Co., Akron 9, Ohio. In Canada: The Bellows Pneumatic Devices of Canada, Ltd., Toronto 18.

What you can't see in the picture is equally important. With the Bellows Air Motor comes the skill and service facilities of more than 125 full time Bellows Field Engineers—men as near you as your phone. They will work with you in applying Bellows "Controlled-air-power" to your designs and they're available quickly to meet any service need.

In your OEM planning take advantage of the savings "Controlled-air-power" offers—and as most manufacturers do—talk to Bellows.

*115 v. for J.I.C. applications, if you prefer.

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

Circle 443 on Page 19

PRODUCT-DESIGN MEMOS FROM DUREZ

Selecting a molding compound | **Fire-retardant prepreg** | **Phenolic battery plugs**

How fast is fast?

When you choose a general-purpose phenolic molding compound, how much emphasis should you place on *fast cure?*

If it's speed you want, you can get it—with Durez 265 Black. Cures on the order of 12 seconds have been run consistently.

But let's look at cure speed another way: what happens if a phenolic cures *too* fast? Plunger speed, mold closing time, depth of draw, flow requirements—all impose *minimum* time limits which vary with the job.

Then, too, as the cycle gets shorter, batch-to-batch *consistency* becomes more critical. A 10% variation in cure speed at 12 seconds means only 1.2 seconds leeway between a good piece and a reject.

(We should mention that with Durez 265 you don't have to worry about consistency, even at this fast cure rate. Its uniformity is carefully controlled to insure reproducible results.)

Doesn't it make sense to be sure to choose a molding compound to *do what you want it to do,* rather than solely for the sake of a few seconds' press time?

Many think so. That's why we also stress Durez 791, 792, and 260 Blacks. Why so many? To give you best results under a host of varied conditions: 791 for greatest versatility; 792 for best dimensional stability; and 260 for easiest machinability.

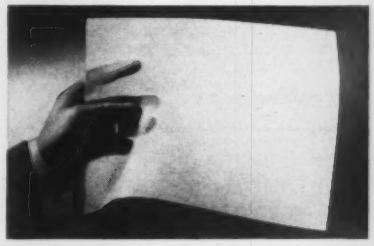
If you'd like to examine for yourself the broad spectrum of properties you can get with these general-purpose compounds, just check the coupon now for data sheets.

Fire-retardant prepreg

Now you can meet the most exacting requirements for reinforced plastic parts that must be strong, tough, and flame-retardant.

You get these properties in a new prepreg, made with Hetron® polyester, that eliminates weighing, mixing, and pouring of resin in your plant.

This material provides exceptionally high tensile, flexural, and impact strengths; smooth glossy surface; and excellent wet-strength retention. It is self-extinguishing without the use of additives.

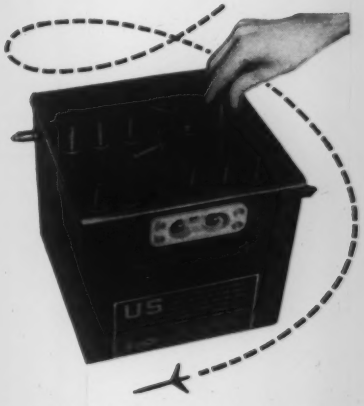


The drapable sheet conforms to complex curvatures, facilitating layup. It is supplied in rolls up to 60 yards long, which have shelf life of six months or more under normal storage conditions.

For a list of manufacturers of prepreg materials, write us. For data on the Hetron resins with which they are made, check the coupon.

Neat stunt

Storage batteries that turn somersaults—and even do barrel rolls—create an



out-of-usual application for phenolics.

These stunting batteries provide ignition and emergency power for military planes. They also pose a design problem: how to vent the cells without losing electrolyte when a pilot puts his plane into a loop.

The answer: a vent with a lead-weighted valve that pops shut as the battery tilts to a predetermined angle, then opens as it returns to level.

Except for the lead weight and one rubber grommet, all parts of the vent plug are made of Durez phenolic. Molded-in threads and valve parts hold close tolerances to prevent leakage and perform within tightly defined limits of tilt, gas pressure, and force of gravity.

This is just one example of the versatility you command when you design with Durez phenolics. Your molder can help you put this versatility to work.

For more information on Durez materials mentioned above, check here:

- ☐ General-purpose phenolic molding compounds (data sheets)
- ☐ Hetron polyester resins (technical data file)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION

HOOKER CHEMICAL CORPORATION

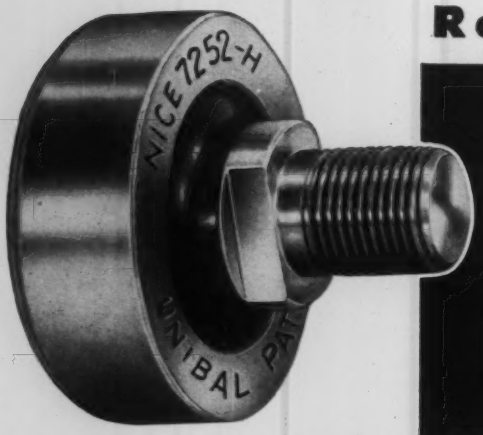
509 Walck Road, North Tonawanda, N. Y.

Circle 444 on Page 19

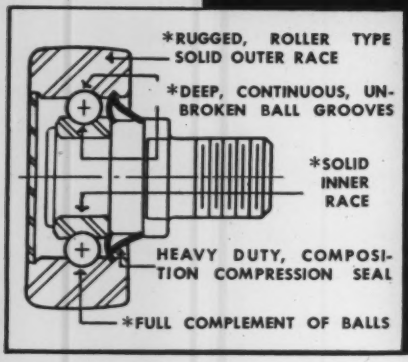
Revolutionary NEW

NICE BEARINGS

Meet...and Beat Tough Application Problems



No. 7252-H—Plunger Guide Roller for Hay Baler


*RUGGED, ROLLER TYPE SOLID OUTER RACE
*DEEP, CONTINUOUS, UNBROKEN BALL GROOVES
*SOLID INNER RACE
HEAVY DUTY, COMPOSITION COMPRESSION SEAL
*FULL COMPLEMENT OF BALLS

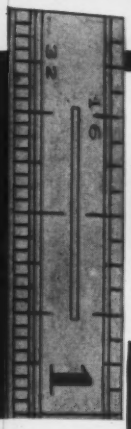
FIELD TESTED AND PERFORMANCE PROVED in a wide variety of tough applications... NICE now offers Product Designers the new and different UNIBAL® Ball Bearing. UNIBAL design and manufacturing methods (patent applied for), produce bearings of exceptional durability and strength. They feature solid inner and outer raceways with deep, unbroken ball grooves... there are no split races or loading slots, yet there is a full complement of balls.

NICE bearing No. 7252-H illustrates the ruggedness of the UNIBAL construction. The UNIBAL features of this plunger guide roller enable it to perform well under adverse conditions of heavy impact loading and a unique new composition seal design (patent applied for) effectively retains lubrication and excludes dust, dirt and moisture.

NICE ball bearings in this UNIBAL design are available in a wide range of sizes and types, with such features as extended races, snap rings, seals and shields. Your Inquiries are Invited.

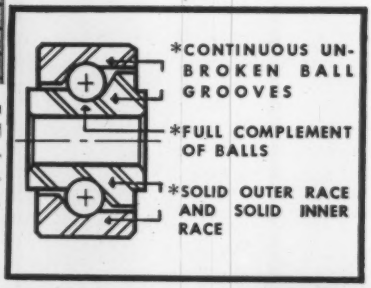
*Unibal FEATURES

Little Jobs can also be TOUGH



NICE No. 6035-H ball bearing is a small, but vital component. Its small size belies its ruggedness and durability under tough operating conditions... another example of UNIBAL superiority.

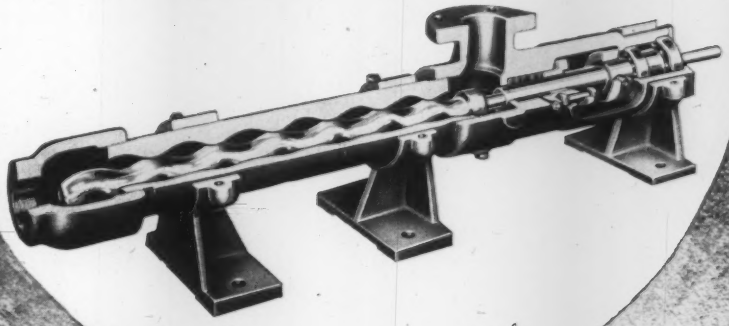
No. 6035-H—Cam Roller Operating Circuit Breaker on Accounting, Calculating and Tabulating Machines.

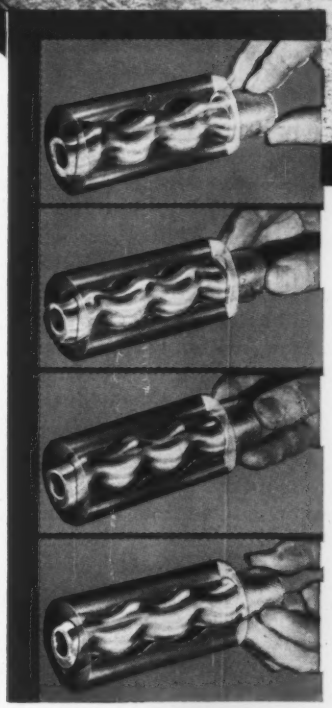


NICE®

NICE BALL BEARING COMPANY
NICETOWN · PHILADELPHIA · PENNSYLVANIA
DIVISION OF CHANNING CORPORATION

IF IT CAN BE PUSHED THROUGH A PIPE... A MOYNO® WILL PUMP IT!





Moyno's exclusive "progressing cavity" principle permits hundreds of formerly "unpumpable" materials to be handled successfully. The screw-like rotor revolves in a double threaded stator forming "progressing cavities" that move the material smoothly without foaming, aerating, crushing or excessive pump wear.

Typical materials pumped include non-pourable pastes, slurries, chemicals, foods, acids, even suspended solids up to one inch in size. Capacities available up to 500 gpm and pressures up to 1000 psi.

No doubt a Moyno Pump can cut costs drastically for you. *Write for Bulletin 30-MD.*

R&M

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO PUMPS PROPELLAIR FANS

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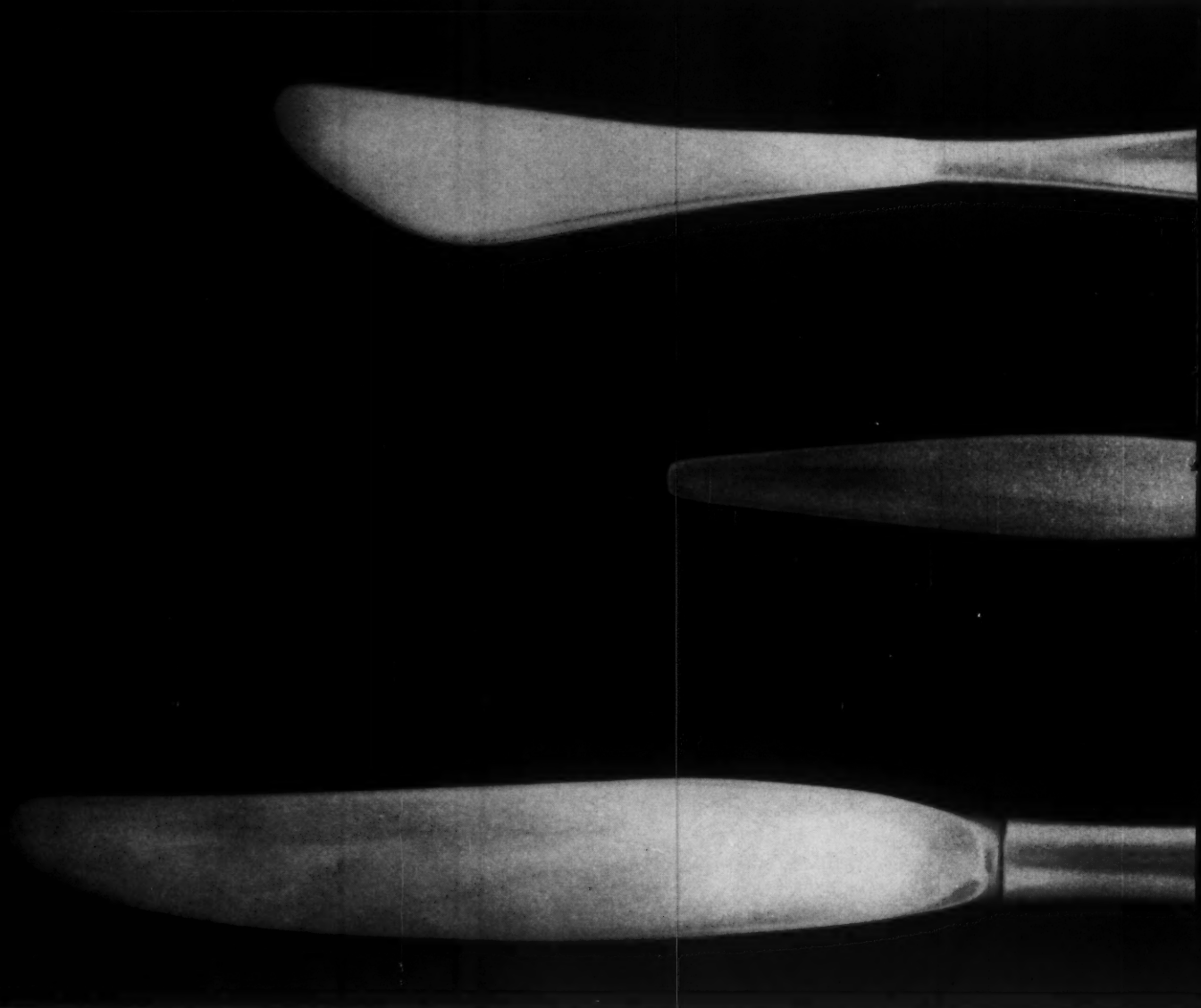


Good Design—Let's say that you were asked to design a *fish*. It's to be the most ferocious monster of the deep, a murderous creature ideally adapted to the sea. Chances are you would end up with something much like a 40-foot-long Great White Shark.

Then assume that you were asked to design the most efficient possible device to span a large body of water. You would very likely end up with something like the familiar high-towered suspension bridge.

You could then take these designs to any great artist and he would say, "They are beautiful"—even if he didn't know how or why you had designed them.

Why are they beautiful? Probably because they are so absolutely functional. In the astringent design of a fish or a bridge, lines are curved only when they should be curved—to add strength or streamlining. *Materials* are used functionally, too. You don't make a shark's tooth from cartilage. You don't make a suspension bridge from anything but steel.

As we develop more and more "styled" products, the choice of material becomes very important. For example, the flatware industry has been revolutionized by Stainless Steel because of its unbeatable combination of luster, strength, corrosion resistance and formability. The landscape gleams with steel curtain wall buildings as we learn to use steel in bold, bright, colorful ways. Even huge power shovels take on a new beauty as ultra-strong steels slim their silhouettes.

It's the same story with thousands of other products. And for any application, there is one steel best suited for the job—one that contains physical properties, appearance and price in the right package. It can be selected from the large family of USS Design Steels: Carbon, High Strength, Alloy and Stainless.

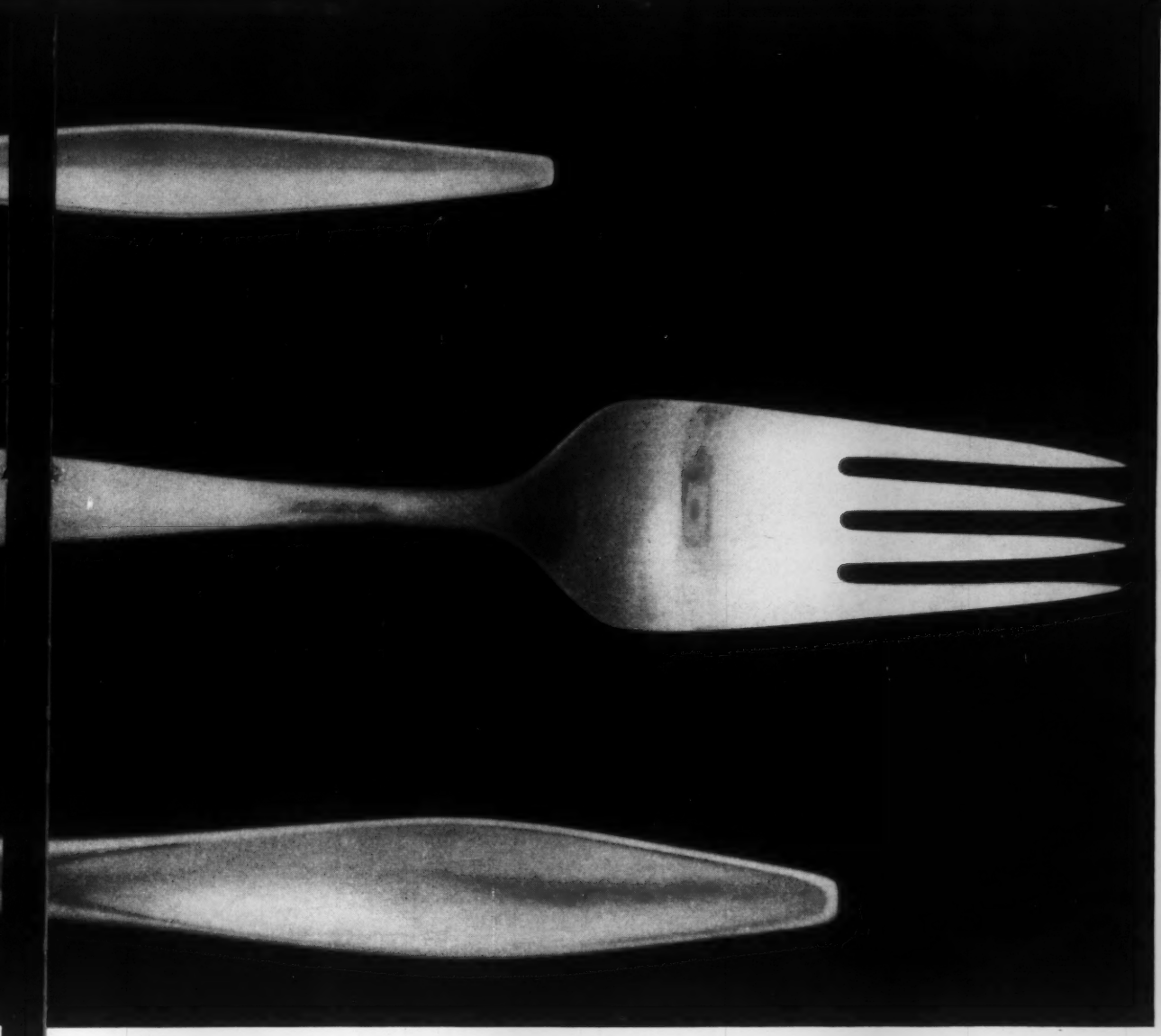
Any time you want help in making that selection, call United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR DESIGN

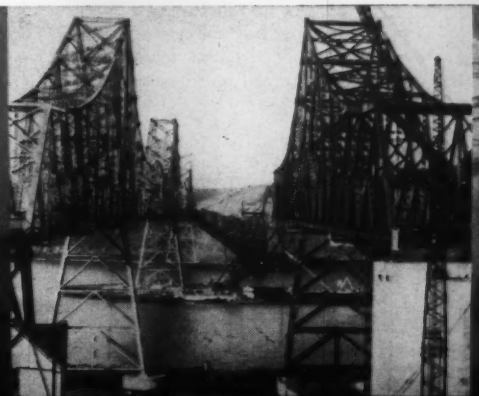


Lower Left: Problem: Combine ruggedness, safety, and beauty in a pleasure yacht. Solution: Designer used USS COR-TEN High-Strength Low-Alloy Steel. Pay-off: Hull is stronger and more resistant to corrosion. Welded construction allowed separation of the gasoline and bilge areas, helps eliminate the most common boat disaster—fire. Formability of COR-TEN made it easy to shape the sleek, curving hull.

Lower Middle: Match profile of a new cantilever bridge (right) with existing bridge, but build it stronger to support wider roadbed. Solution: USS "T-1" Constructional Alloy Steel (now available at 100,000 psi min. yield strength) and USS TRI-TEN High-Strength Low-Alloy Steel. Pay-off: "T-1" Steel alone saved $800,000 by slimming down massive members. All shop connections are welded. "T-1" 's weldability enabled clean, graceful members contrasted to laced and riveted members in old bridge.

Lower Right: Problem: Portray 20th century Pittsburgh in a metal mural for a Pittsburgh hotel. Solution: Artist selected Stainless Steel for most of the job. Pay-off: A mural that is permanently beautiful. Says sculptor Rene Shapshak, "This is the Stainless Steel Age."

USS, "T-1", Cor-Ten and Tri-Ten are registered trademarks



Technical data for gasket design and selection

NUMBER FOUR

Why close tolerances in resilient gaskets are rarely necessary

Tolerances in the size and shape of a gasket do not become critical if the gasket material chosen seals effectively over a wide range of compressions.

The typical examples shown here illustrate how Armstrong cork-and-rubber materials help eliminate the need for close tolerances.

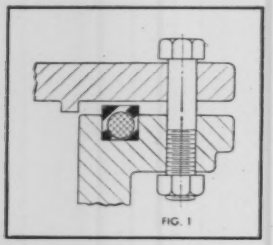


FIG. 1

Figure 1 shows relative sizes of a resilient cork-and-rubber gasket and a non-compressible molded ring. The ring must meet very close tolerances to allow flange contact and achieve a seal.

In figure 2, wide tolerance cork-and-rubber gaskets make an effective packing ring. True compressibility controls lateral flow and prevents excessive build-up of radial pressure on the shaft.

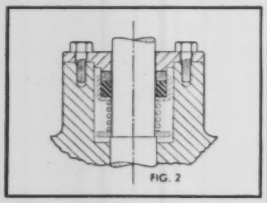


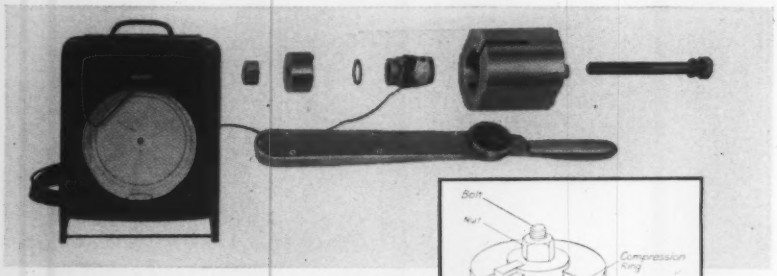
FIG. 2

Armstrong cork-and-rubber compounds seal tightly under compressions ranging from 20% to 33%. Because they are truly compressible, they decrease in volume under load, so tolerances in size may be as wide as .010", even in completely confined space.

How varying bolt efficiencies affect flange loads, cause gasket leakage

Leaks often occur in gasketed joints where flange loads as calculated are thought to be adequate—or more than adequate—to create a seal. Such leaks are sometimes blamed on torque loss, when the real problem is inadequate initial flange pressure.

Data obtained with this device has led to a method of relating apparent flange pressures to actual flange pressures. This procedure compensates for loads that approach the values calculated from bolt torque.



Studying efficiency of ⅝-11NC bolt. The bolt is inserted from bottom of housing and load sensing transducer slipped over with its wires leading through keyway to recorder. Keyed compression ring is then fitted on, and the nut is torqued. Variations in loading for a given torque, caused by friction on threads and bolt head, are traced by the recorder.

The major reason is that flange loads arrived at mathematically almost never equal the true load on the gasket. The explanation is friction . . . friction on threads and bolt heads that soaks up torque and reduces the pressure available to squeeze the gasket.

Although it is generally known that friction causes variations in bolt efficiency, little data has been available to indicate the extent of the problem. As a result, arbitrary compensations for friction are usually too low.

Armstrong research engineers have developed a device (shown above) which measures the effect on bolt efficiencies of varying screw thread conditions. Dry or rough threads, for example, give low bolt efficiencies which develop actual gasket loads much lower than torque readings would indicate. Lubricated threads give high bolt efficiency and result in gasket varying conditions of bolt threads.

This data, combined with other new information on seal points of Armstrong resilient gasket materials, is useful in helping designers meet the minimum sealing conditions of a particular flange design and material.

Detailed information on this subject and other problems of gasket selection, design, and performance is contained in the new Armstrong Gasket Design Manual. Write for your personal copy.

New! Gasket Design Manual just printed. Write for a copy to Armstrong Cork Company, Industrial Division, 7509 Dean Street, Lancaster, Penna.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

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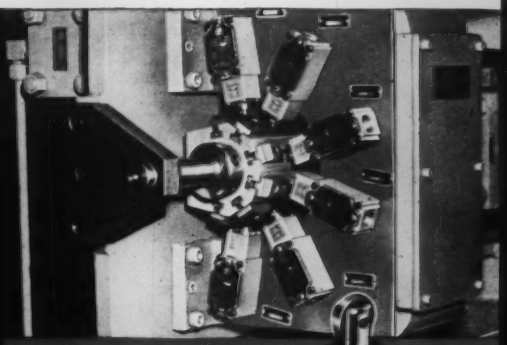
Circle 448 on Page 19→

ALLEN-BRADLEY

BULLETIN 802T

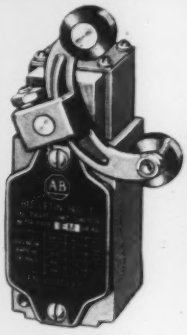
OILTIGHT

LIMIT SWITCHES

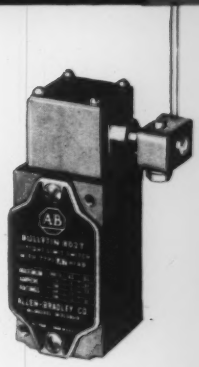


Radial mounting of six Allen-Bradley "manifold" type, push roller, oiltight limit switches.

SIDE PUSH ROD



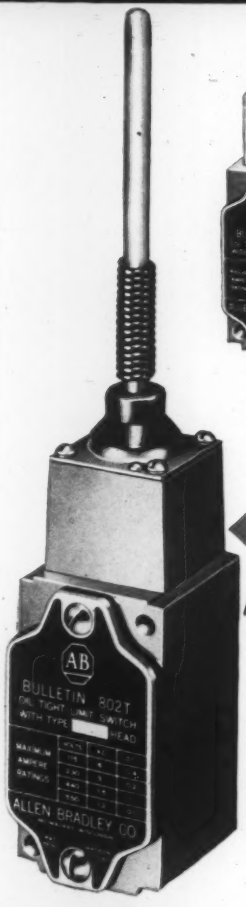
FORK LEVER TYPE



ADJUSTABLE ROD

TOP PUSH ROD WITH PLASTIC WINDOW

Push roller, oiltight limit switch, showing rubber grommeted wiring hole on back of "manifold" type, used on above automatic production machine made by Cross Company, Detroit.



WOBBLE STICK TYPE

OIL SEALED HEAD AND BODY

assure reliable operation

Completely sealed . . . oil, dirt, and metal chips cannot foul up contacts or operating mechanism. Operating heads are interchangeable—can be mounted in any one of four positions. New "wobble stick" heads operate in any direction. All of these limit switches have maintenance free, double break, silver alloy contacts. Specify Allen-Bradley—the *quality* line of limit switches.

ROLLER LEVER FOR CAVITY MOUNTING

ADJUSTABLE ROLLER LEVER

A-B QUALITY

ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

9-58-R

THE ONLY LINE OF

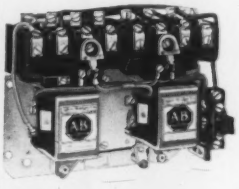
D. C.
MOTOR STARTERS
with modern
SOLENOID CONTACTORS

With Allen-Bradley, you get D. C. motor control that is *completely modern!* It uses the simplest switching mechanism yet conceived . . . the solenoid contactor with only ONE moving part. There are no bearings to stick . . . no jumpers to break. This assures millions of trouble free operations. And the double break, silver alloy contacts never need maintenance. Available in ratings up through Size 4. Write for details.

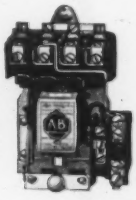
CONTACTORS

Bulletin 202 solenoid type contactor. In ratings to 150 amp. Also, clapper type to 600 amperes.

FULL VOLTAGE STARTERS

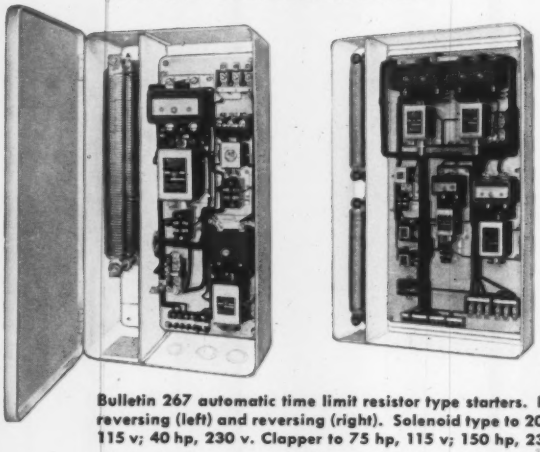


Bulletin 205 full voltage reversing starter. Ratings to 1½ hp, 115 v; 2 hp, 230 v.



Bulletin 209 full voltage starter. Available in ratings up to 1½ hp, 115 v; 2 hp, 230 v.

REDUCED VOLTAGE STARTERS



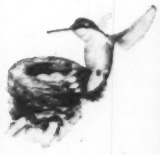
Bulletin 267 automatic time limit resistor type starters. Non-reversing (left) and reversing (right). Solenoid type to 20 hp, 115 v; 40 hp, 230 v. Clapper to 75 hp, 115 v; 150 hp, 230 v.

9-58-MR

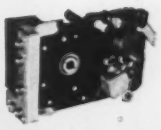
ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

MAIN OFFICE and Factory
1316 S. Second St.
Milwaukee 4, Wis.

In Canada: Allen-Bradley Canada Ltd., Galt, Ontario



Hummingbirds Are Power-Packed...have more energy for their size than an elephant. Smallest hummingbird is only 2⅜″ long, builds a nest only 1″ square with cobwebs. The hummingbird is one of nature's greatest masterpieces in miniaturization.



Miniature Tape Recorder fits in briefcase . . . operates on hearing-aid batteries yielding 1/8000 h.p. This is possible because friction is reduced by two MPB bearings installed on the main drive shaft. Another man-miracle in the world of miniaturization.

Man With Miracles. This is Bill Timmerman, one of MPB's Sales Engineers. He helped the tape recorder people find exactly the right type of bearing to reduce friction to a minimum, give failure-proof service and help keep original and maintenance costs low.

More Miracles in Miniaturization to come

BEARING ACTUAL SIZE

It's just starting. Industry is on the threshold of new miracles in the world of miniature mechanisms. Best help in the problems will be MPB who has the world's greatest wealth of experience in the application of miniature bearings ⅜″ O.D. or less. MPB has more than 500 types and sizes, specials on request, engineering and research facilities second to none. You'll want to know more about miniaturization and the promise of progress it holds. For engineering aid and/or new catalog write **Miniature Precision Bearings, Inc.,** 109 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

Circle 449 on Page 19

MEL-TROL® gives you **design insurance** on high temperature parts like this

You design for consistent performance. Production demands consistent fabrication properties. You have to have both.

If high temperature alloys don't give you both, there is usually just one reason—lack of uniformity. And you can trace it right back to the original ingot your alloy came from.

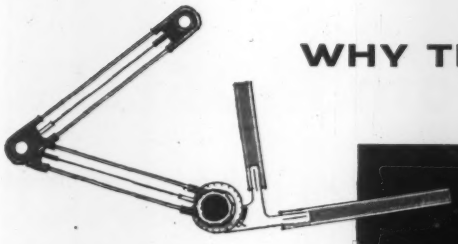
Variation in toughness or alloy content between centerline and material nearer the surface of an ingot cannot be removed by any amount of working. Troubles pass from ingot to bar to rod to wire—to you.

MEL-TROL stops this kind of trouble before it can start. Throughout the steelmaking process, the newest and most accurate quality controls guard MEL-TROL alloys. Steel is poured into the new, *Carpenter*-patented ingot mold that produces greater uniformity in the ingot than any other method now used in steelmaking.

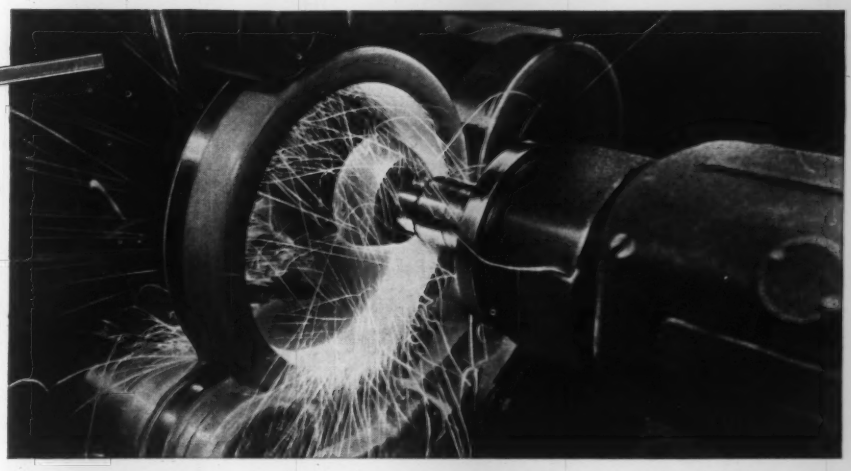
The result is more consistent fabrication behavior and better finished parts. MEL-TROL also pays dividends in high temperature performance over and above conventional steels. Insure the producibility and performance of *your* high temperature designs with MEL-TROL alloys. Call *Carpenter* for the alloy you need, today.

Carpenter STEEL

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS



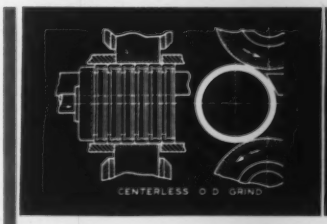
Grinding the flange on a HYATT outer race.

PRECISION FINISHING OF HYATT OUTER RACES HELPS ASSURE LESS HEAT AND VIBRATION . . . BETTER BEARING PERFORMANCE

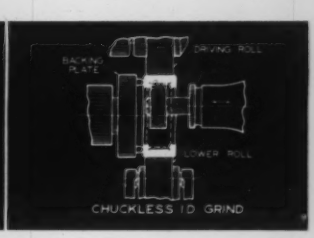
Outer races usually are not the critical members of a roller bearing, but they provide vital fatigue-resistant roller pathways in all applications where hardened and ground housings are not feasible. The better they are built, the smoother and longer the entire bearing will perform.

So HYATT manufactures outer races with the same scrupulous care that is applied to all other components of HYATT Hy-Roll Bearings. After careful primary machining and heat treating, the outer race ends are faced off square and parallel by a double end grind. This provides a reference surface from which all runouts and squareness can be gaged in the subsequent operations shown at right.

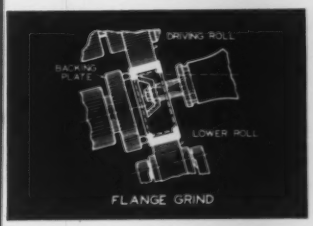
You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Pittsburgh, Detroit, Chicago, and Oakland, California.



Through-feed centerless grinding provides an O.D. with minimum out-of-round and helps reduce costs.

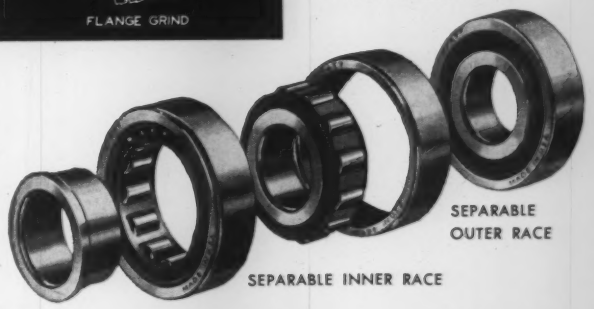


Next, race is driven on O.D. and ground centerless to generate an I.D. cylinder concentric with O.D.



Flanges are ground using race ends as reference. Result is race of as nearly perfect geometry as practical.

NON-SEPARABLE TYPE



SEPARABLE OUTER RACE

SEPARABLE INNER RACE

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

1908–1958 GM FORWARD FROM FIFTY

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

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NOW.. from MUELLER cold·prest® IMPACT

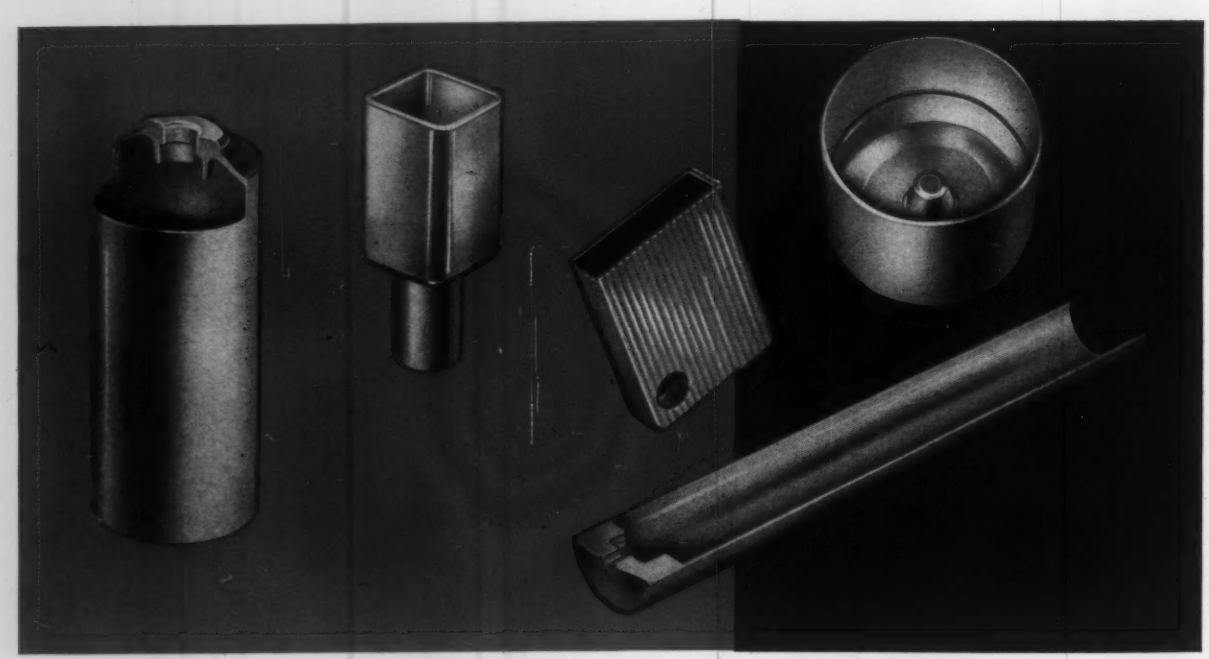
the amazing, new, chipless metalworking method that cuts production costs... ....improves part quality

Cold-Prest Impact Extrusions are here. This amazing new method of producing parts to closer tolerances . . . with better physical characteristics, and with absolutely no waste and at extemely high speed is the greatest development in metal-working in the last 20 years. And it's proving to be the most practical method of manufacturing a staggering number of designs that combine cold forged bases with shells shaped as rounds, ovals or rectangles.

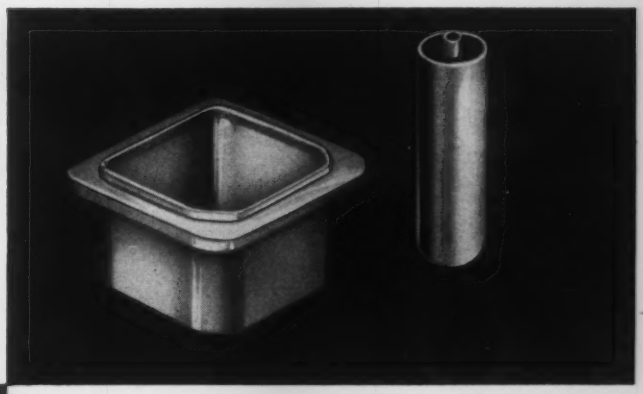
Here are some of the reasons why your company can save money and improve product quality . . . by specifying Mueller Brass Co. Cold-Prest Impact Extrusions. Parts are formed with *no chip loss;* you pay only for the metal that goes into the part. Because of the dimensional accuracy of Cold-Prest extrusions, parts can be held to closer tolerances and many costly secondary machining operations are eliminated. They have better physical properties with actually less metal needed to achieve greater strength.

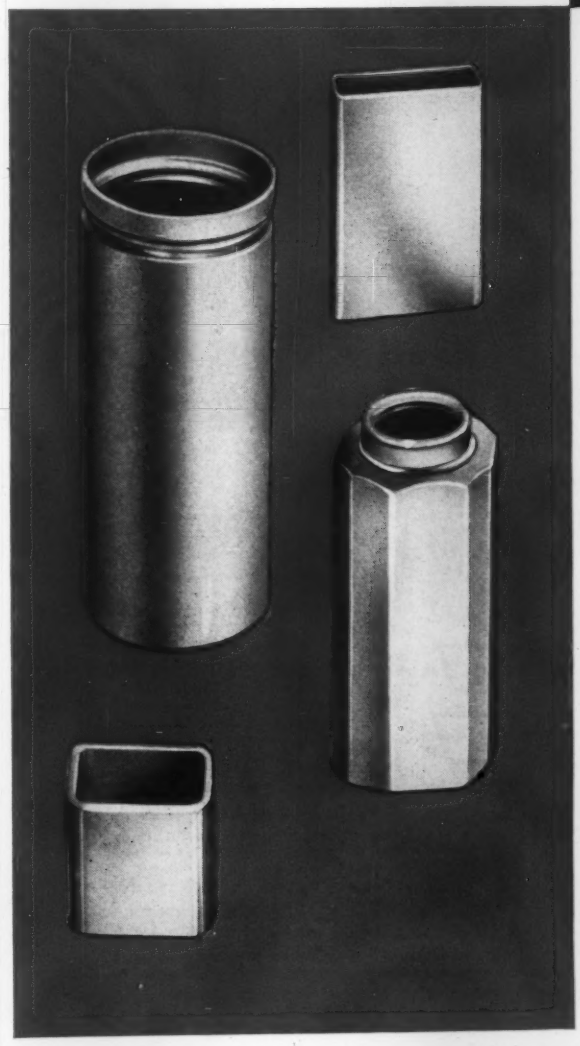
Cold-Prest Impact extruded parts often *reduce or eliminate assembly operations* because products employing several parts can often be made as a single extrusion. Also, complex parts produced by conventional methods requiring costly machining to close tolerances can be made in *A SINGLE OPERATION* as a Cold-Prest extrusion, saving raw material, costs of time, tools and labor . . . as well as assuring a positive leak-proof part.

These are the outstanding reasons why you should consider Cold-Prest Extrusions when you are specifying and purchasing fabricated metal parts. Call a Sales Engineer from the Mueller Brass Co. . . . he will be glad to discuss your problems and answer your questions. Write today for our new 16 page engineering manual on "Cold-Prest Impact Extrusions".



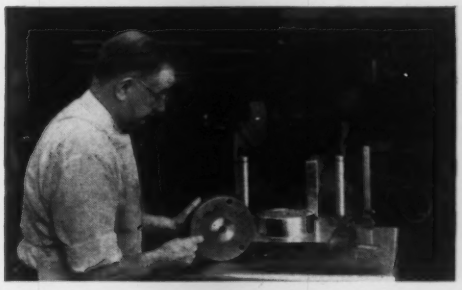
BRASS CO. EXTRUSIONS





MUELLER BRASS CO. SERVICES mean better designed, better engineered, lower cost cold-prest extruded parts

To produce precision, high quality impact extrusions, Mueller Brass Co. combines all the important factors of design, engineering and production in its Cold-Prest extrusion process. Trained engineers take into consideration such elements as functional strength, finished appearance and proper control of metal flow. Mueller Brass Co. offers this design engineering service to its customers, and engineers are always available for consultation.



Here a die and punch assembly, made to exacting tolerances and with a mirror-like finish, receives a final inspection in the tool and die shop before being sent to the production department. Skilled craftsmen work with the best equipment available to produce these precision tools and dies. Technical skill, modern equipment and complete engineering services are available at no extra cost to you.

MUELLER BRASS CO.

MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY

259

PORT HURON 20, MICHIGAN

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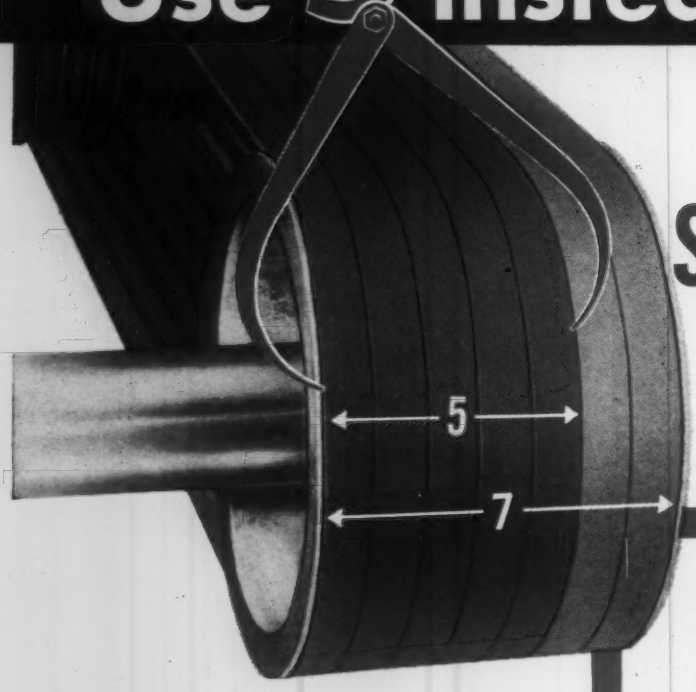
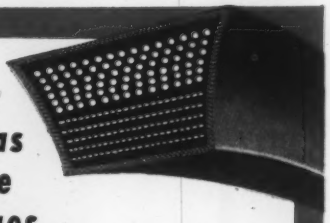
Use 5 instead of 7...

save { space / weight / cost





***Money-saving fact:* A Gates Super Vulco Rope Drive delivers more HP per dollar invested than *any* standard V-belt drive.**

By using belts with 40% more horsepower capacity, you reduce sheave width and weight — save substantially in overall costs.

A wealth of drive data is always quickly available to you. Whether you need drive design service — or V-belts — or sheaves — just call your nearby Gates Distributor for a Gates V-Belt specialist.

Stocks carried in industrial centers throughout the world.

Gates Distributors are in the Yellow Pages

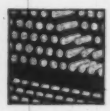
The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates — The Mark of *Specialized* Research

No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.



3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads ... reduce number of belts required ... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 341

Gates Super Vulco Rope Drives

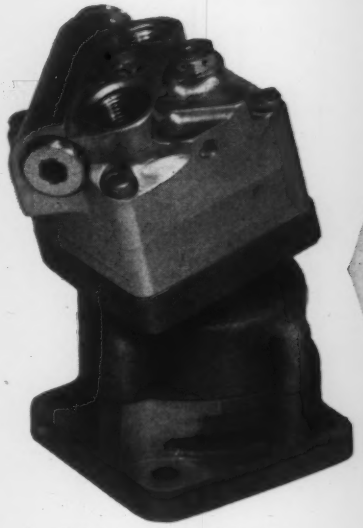
40% more Horsepower Capacity

FOR AIRCRAFT AND MISSILE APPLICATIONS:

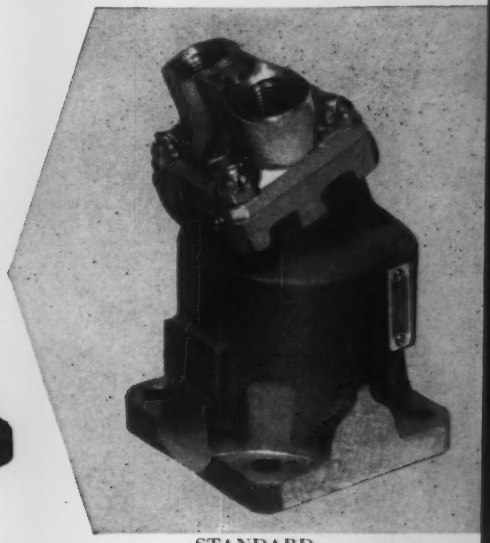
Variable Pump Design Breakthrough!

... by VICKERS

Variable hydraulic output from constant displacement package



NEW MINIATURIZED
VARIABLE DISPLACEMENT
3906 Series ■ Weight...2.4 lb



STANDARD
CONSTANT DISPLACEMENT
3906 Series ■ Weight...2.1 lb

- 48% weight reduction—70% smaller envelope*
- 12,000 rpm for aircraft applications
- 18,000 rpm for missile use
- 24,000 rpm for intermittent duty
- 9.7 gpm delivery at 24,000 rpm
- 17 hp (over 7 hp/lb) at 24,000 rpm and 3000 psi
- 98% volumetric efficiency—92% overall efficiency
- Uses proven Vickers 3000 psi rotating pumping element
- Integral automatic pressure compensator
- Extremely rapid response
- Minimum external sealing elements
- Minimum number of moving parts*
- Broad range of control methods available
- First of a new complete line
- Power saving (and heat rejection) advantages of variable displacement at fixed displacement weight and envelope.

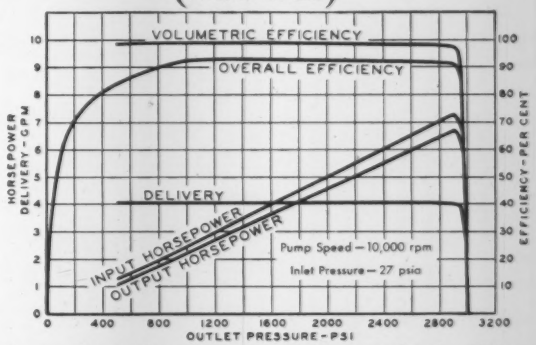
*Compared to standard 3000 psi Vickers Series PV-3906 variable displacement axial piston pump.

For further information write for Bulletin No. A-5233.

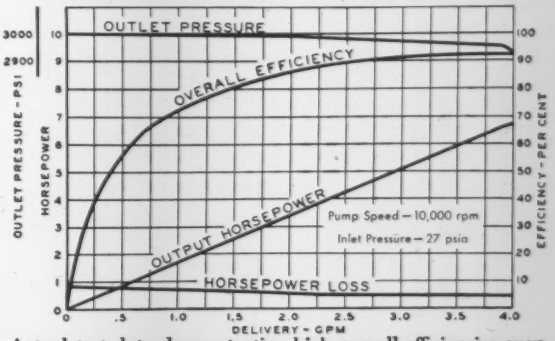
VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Aero Hydraulics Division
Engineering, Sales and Service Offices:
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan
TORRANCE, CALIFORNIA • 3201 Lomita Boulevard
P.O. Box 2003 • Torrance, California

8070

Performance Characteristics of Model E-0011111 Pump
(PV-3906 -30° Size)



Curves above show actual performance of new Vickers variable delivery pump. Note exceptionally high volumetric and overall efficiencies throughout broad outlet pressure range.



Actual test data demonstrating high overall efficiencies even at partial flows for the new Vickers variable delivery pump. Note low horsepower loss throughout entire delivery range.

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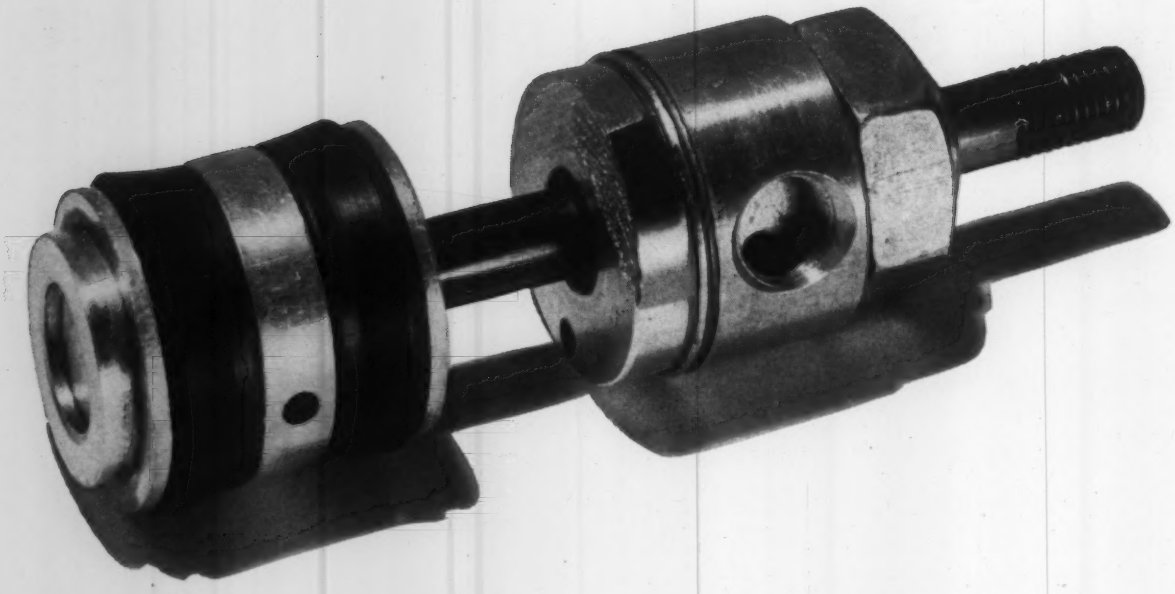


Like NEW—after 1,600,000 Cycles!

. . . due to the right combination of packings and engineering

That's right, 1,600,000 cycles. The picture is about twice actual size, unretouched. The application: a Model 091-D double acting air cylinder produced by Bimba Manufacturing Co., Monee, Illinois.

The designer got excellent results for two reasons. One: he specified and insisted on a close, smooth inside finish. Two: he specified Houghton Vix-Syn "U" Cups.

He knew—as so many engineers are discovering—that Houghton Packings of any standard material—rubber, fabricated rubber, wax or rubber-impregnated leather—will give a bonus in long wear and reliability in correctly designed pneumatic and hydraulic equipment. And he also knew Houghton backs up packings with prompt engineering service when it's needed.

Why not make Houghton your packing headquarters? Don't settle for less than the foremost packing know-how in the business. Specify Houghton packings. Free folder gives engineering features and lists all sizes available. Write E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

VIX-SYN "U" CUP PACKINGS

. . . products of

E. F. HOUGHTON & CO.

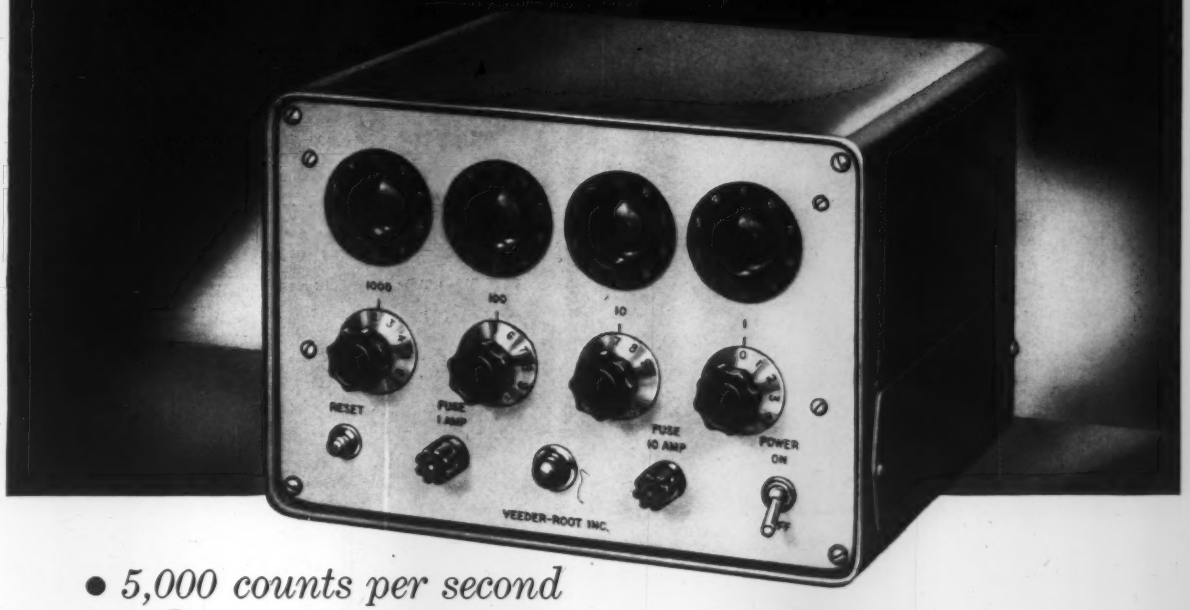
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Circle 455 on Page 19

NEW

TRANSISTORIZED PREDETERMINING COUNTERS



- *5,000 counts per second*
- *Instantaneous recycling*
- *Increased reliability*
- *Industrial design*

A versatile group of transistorized production counters designed for industrial applications. Any number of decades can be furnished depending upon your requirements.

Can be operated by non-technical help merely by setting the selector knobs to the pre-set quantity within the range of the instrument. These counters are ideal for batch control, sequential predetermining, or accurate length control in such applications as packaging, coil winding, slitting, stacking and material handling.

The use of transistors means that heat — the enemy of reliability — has been eliminated. This reduces warm-up time and increases dependability. Printed circuits and simplified wiring further insure long trouble-free operations.

Standard counters are completely enclosed in attractive industrial cases, but can also be supplied without enclosures for panel mounting. A photo head to actuate these counters can be furnished in many configurations. Batch totalizers with push-button reset and special modifications of basic components can be furnished on request.

This is your complete package for predetermining counting at high speeds. Send for your copy of the new specification bulletin outlining the complete range of the series 1604 counter line today.

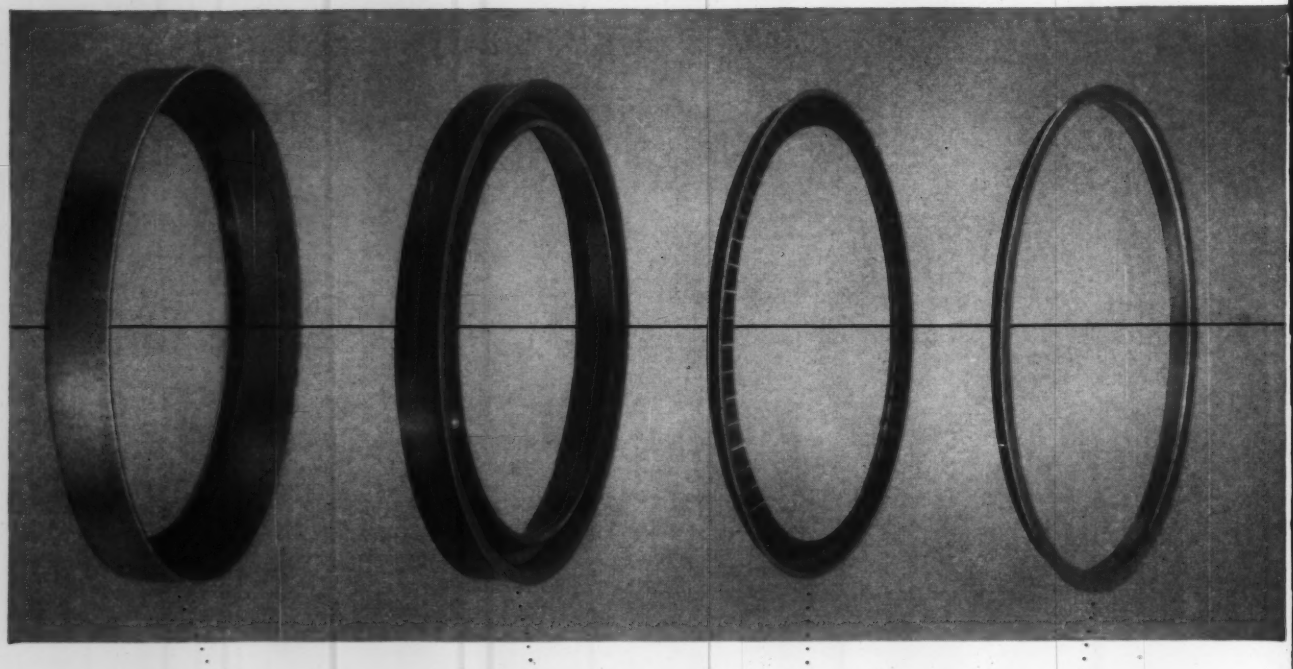
Veeder-Root
INCORPORATED
Hartford 2, Connecticut

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago • New York
Los Angeles • San Francisco • Montreal • *Offices and Agents in Principal Cities*

Circle 456 on Page 19

MORE OF THE GARLOCK **2,000**

Put 'em all together . . .



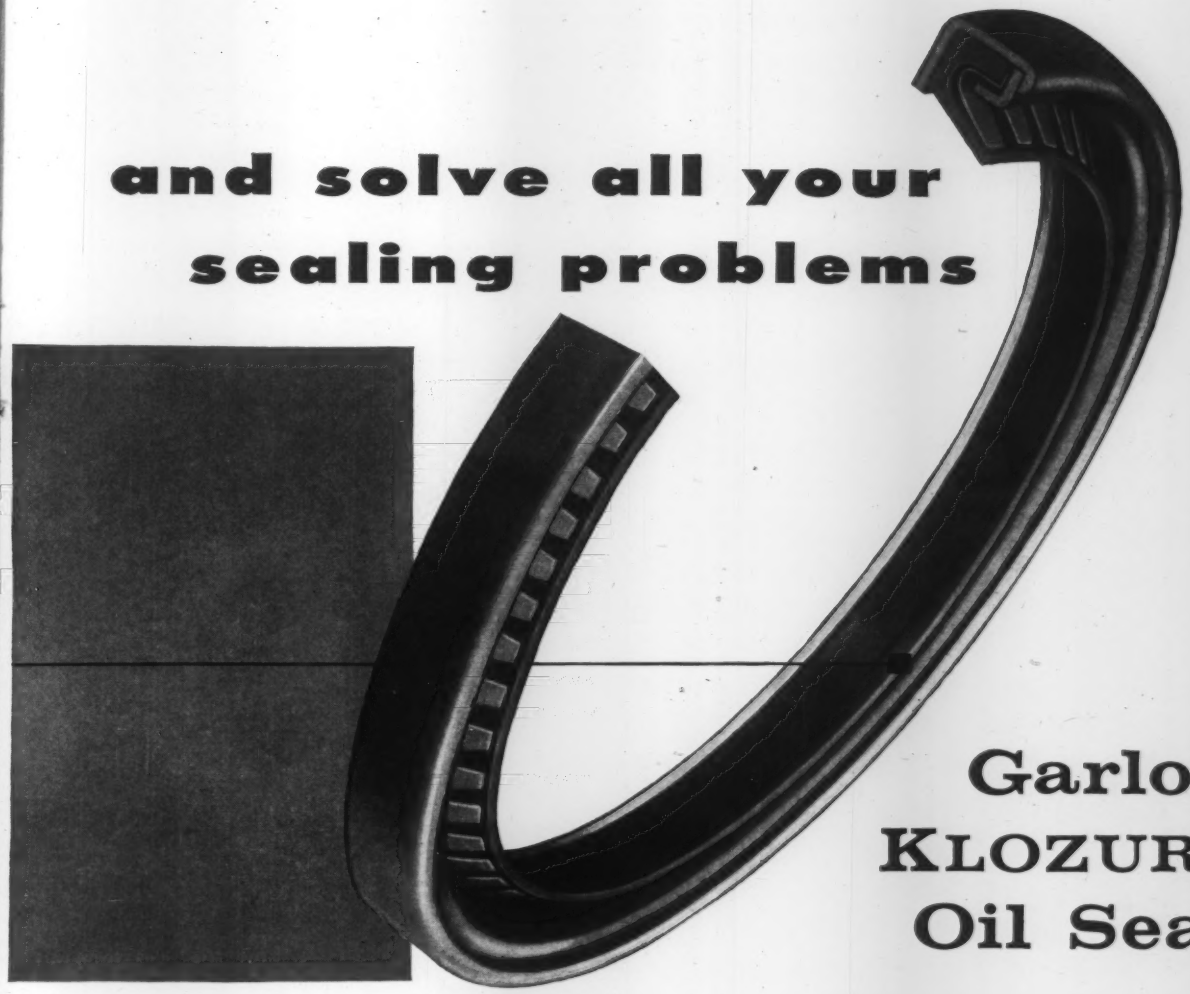
PRECISION FORMED CASE, held to ±.002" dia., has a polished smooth finish . . . no grinding is needed, therefore KLOZURE cases are of uniform thickness throughout, no thick-and-thin areas. Also, the danger of trapping grinding abrasives in the assembly is entirely removed.

THE FINGER SPRING is second only to the sealing element in importance. This one is a distinctive Garlock development which supplements the resiliency of the sealing element in Garlock KLOZURES. It is free to move with the sealing element, and is so precisely tempered that it retains its flexibility throughout the life of the seal. Other conventional springs are also available.

SEALING ELEMENTS in Garlock KLOZURE Oil Seals are made in a variety of shapes from Buna N, Polyacrylate, Silicone Rubber, Viton A, or Teflon, depending on service conditions. For example, where extreme heat and high speeds are encountered silicone rubber may be desired. Where acids or other chemical conditions exist, Teflon may be desired. In any case, the dependability of the seal is largely determined by the design and construction of the sealing element. Therefore, Garlock offers a wide choice to exactly suit every job.

THE ADAPTER holds and locates properly the sealing element and spring in the metal KLOZURE case.

and solve all your sealing problems



Garlock KLOZURE* Oil Seals

MODEL 53 for larger shafts under normal service

MODEL 71A Springless KLOZURE for excluding dirt or retaining grease

MODEL 63 for normal and high-speed service

Split KLOZURE for installation without disassembly of equipment

Every part of KLOZURE Oil Seals is engineered to give superior service on the job for which it is intended. Through the various combinations of sealing elements, springs, and cases, the proper KLOZURE Oil Seal can be developed for any requirement. Whether your sealing problem involves high shaft speeds or temperatures; corrosive liquids, synthetic fluids, or limited space . . . there is a Garlock KLOZURE Oil Seal to solve it. Why not investigate and see?

Remember KLOZURE Oil Seals are only part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. It's the only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today, or write for KLOZURE Catalog.

Registered Trademark

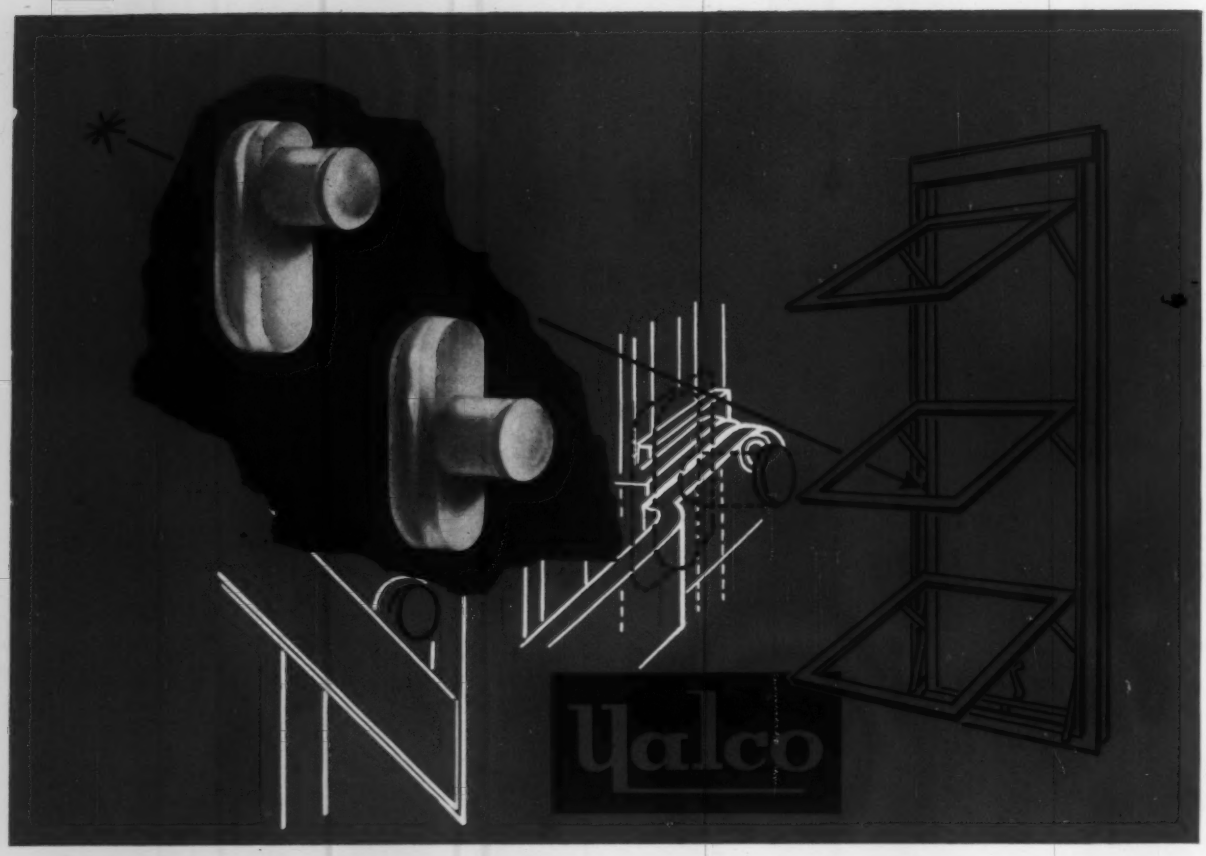
THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

Circle 457 on Page 19



Molded Nylon Parts by . . .

Quinn Berry of Course

Contributing vitally to the smoothly noiseless operation of Ualco Residential Awning Windows, are these molded nylon parts engineered and produced by Quinn-Berry.

In the linkage controlling the raising and lowering operation, these parts, actual size as shown above, function not only quietly and smoothly—they are tough, wear resistant "bearings" concealed within the aluminum frames. The high quality molded nylon parts add an extra value to these popular windows made by Southern Sales Sash and Supply Co., Inc. of Sheffield, Alabama.

This is but another example of the diversity of Quinn-Berry capabilities in engineering and producing components of molded thermoplastics to improve end products in world wide daily use.

Consult with us in full confidence that here, at Quinn-Berry, the "Unusual is Routine". We can serve you well.

CHELSEA 50, Mass.
Joseph Leader
68 Marlborough Street
Chelsea 3-3484

CHICAGO 45, Illinois
R. H. Frish
Room 211
6349 N. Western Ave.
Ambassador 2-6005

DETROIT 35, MICH.
Harry R. Brethen Co.
16115 Meyers Road
Diamond 1-3454

EAST ROCHESTER, N. Y.
Dynatherm, Inc.
607 West Commercial Street
Phone: Ludlow 6-0082

KNOXVILLE, Tennessee
Harold J. Melloy
2100 Ailor Ave.
P. O. Box 3207
Phone: 2-5911

MILWAUKEE 13, Wis.
John Weiland, Jr.
7105 Grand Parkway
Greenfield 6-7161

ARDMORE, Pa.
Austin L. Wright Co.
P. O. Box 561
1 W. Lancaster Ave.
Midway 2-5113

WE FLY TO SERVE YOU FASTER!

QUINN-BERRY CORP.
CUSTOM MOLDERS OF ALL TYPES OF THERMOPLASTICS
2609 WEST 12TH STREET, ERIE, PA.

Circle 458 on Page 19

Knee high to a grasshopper

but Fenwal's New Miniature, Hermetically Sealed THERMOSWITCH® Unit is Strong as an Ox

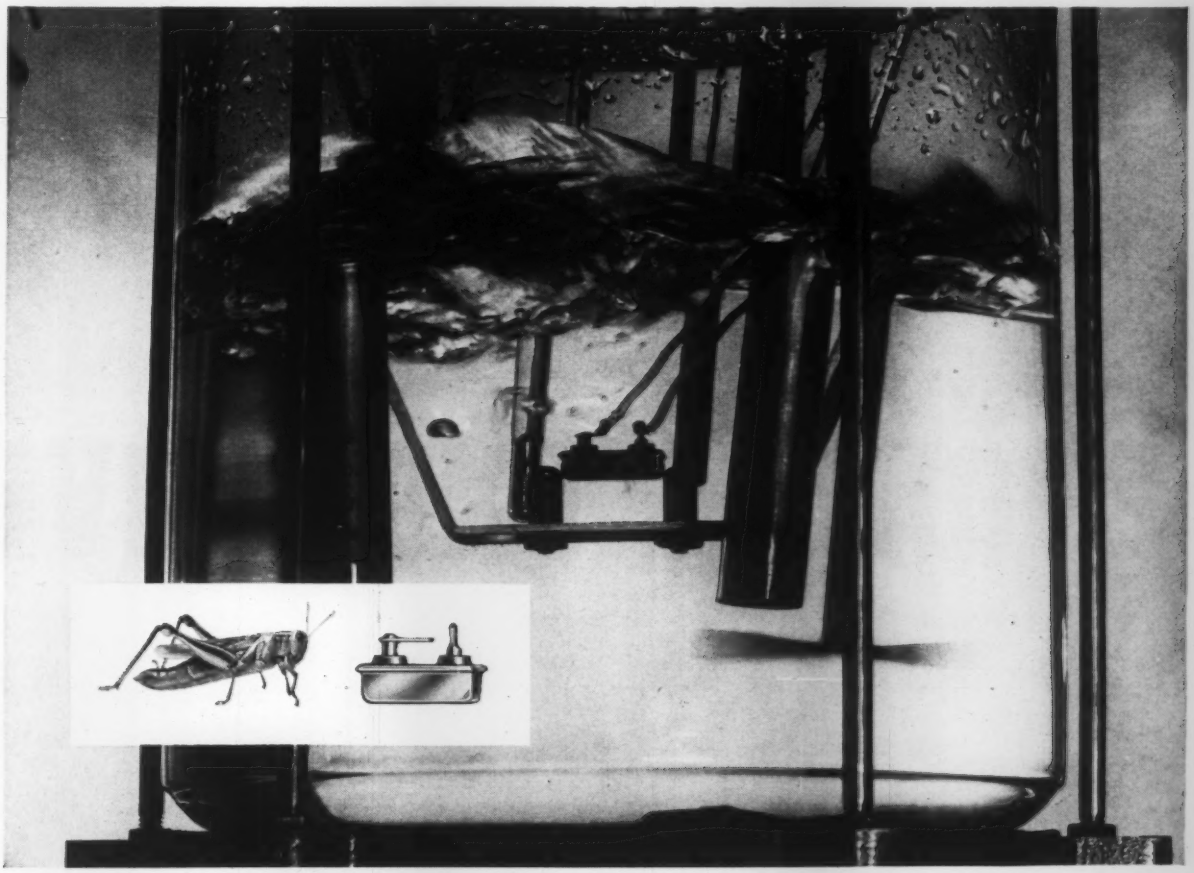
Here are acute temperature sensitivity, instant response, and the strength to withstand the most demanding conditions — all in *one unit only knee high to a grasshopper!*

It's hermetically sealed, yet field adjustable. Maintains control characteristics even with vibrations of 500 cps with 10G acceleration — *it's rugged!*

You get wide range and sensitivity, too. The new THERMOSWITCH unit controls temperatures from −20° to +200°F within 1°. Thin wall corrosion-resistant, drawn stainless steel case insures instant response to temperature changes — *you get precision control.*

You'll want to find out more about this tiny, tough, sensitive control. For more information on the new miniature hermetically sealed THERMOSWITCH unit, and other Fenwal miniaturized controls, write for our catalog or a sales engineer. Fenwal Incorporated, 199 Pleasant Street, Ashland, Massachusetts.

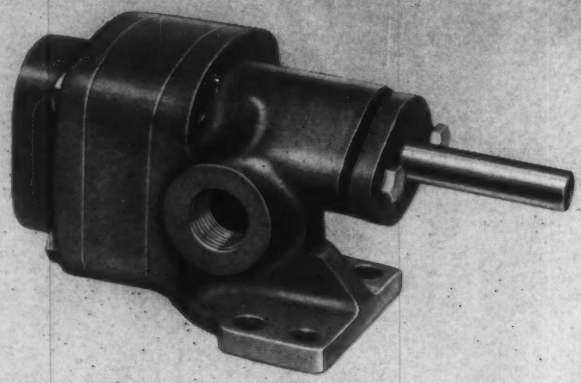
New Fenwal miniature THERMOSWITCH unit being agitated in liquid bath while maintaining temperature of liquid at 140°F ±1°. THERMOSWITCH unit weighs less than ¼ oz., can withstand 10G acceleration at 500 cps vibration. Current capacity is 2.5 amps, 115 VAC, 2.0 amps, 28 VDC.



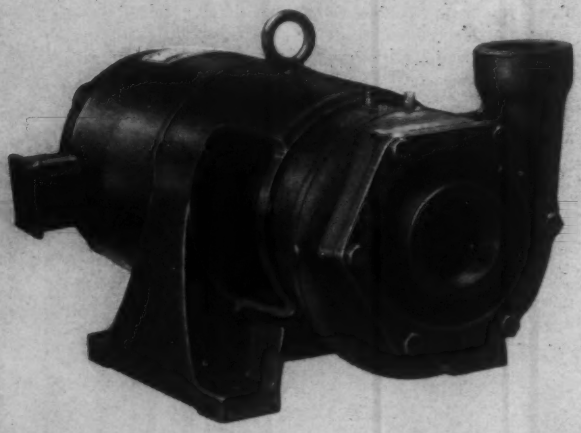
Fenwal CONTROLS TEMPERATURE . . . PRECISELY

Circle 459 on Page 19

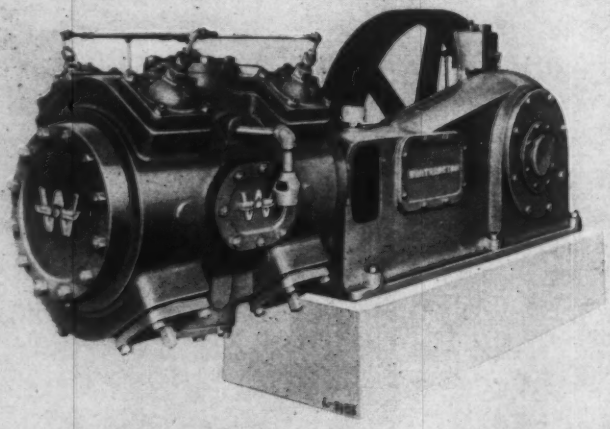
Monobloc Rotary Pump



Rotary Pump



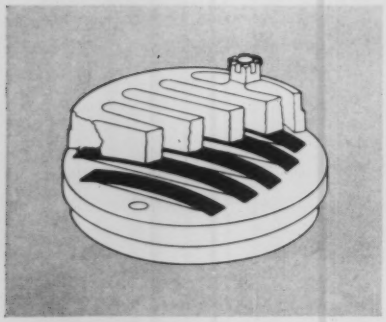
Monobloc Centrifugal Pump



Water-cooled Compressor

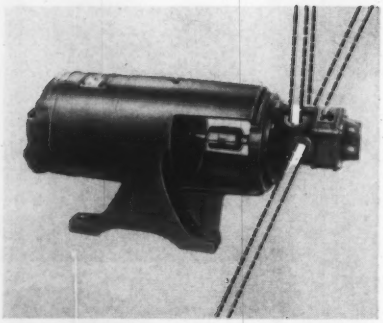
On any pump or compressor you choose, only Worthington gives you these

EXCLUSIVE

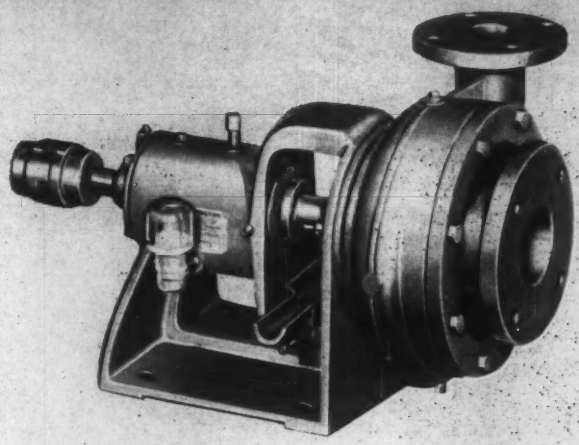


Feather Valve Lightest, fastest-acting compressor valve available. Works with no impact, is all but indestructible, and has an amazing record of long life with negligible maintenance costs.

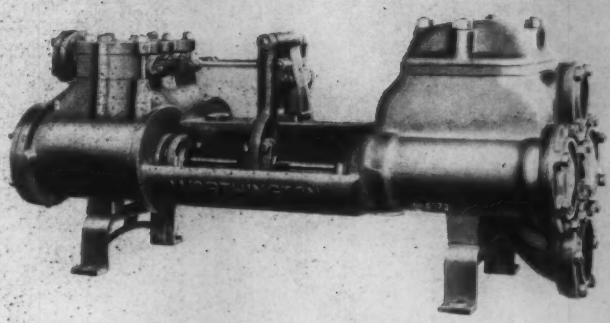
70,480 Combinations Completely standard and interchangeable components let you save up to 50% on spare parts inventory, permit you to design and build over 70 thousand "special" pumps using but 6 SESC pumps.



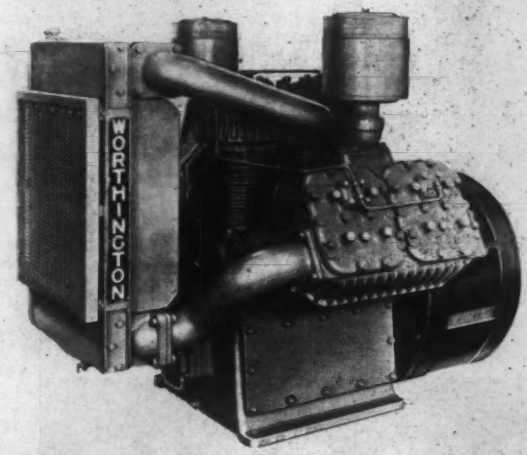
Monobloc Rotary Pump Eliminate alignment problems, simplify layouts by choosing up to 28 different ways to hook up pump piping. Saves you time, materials, is less expensive than separate pump, motor and baseplate.



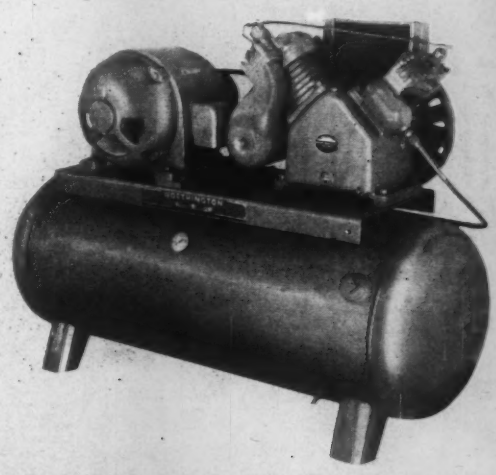
Chemical Centrifugal Pump



Steam Pump



Radial Air-cooled Compressor



Balanced Angle Air-cooled Compressor

DESIGN ADVANTAGES

Designing and manufacturing outstanding products has been a success story typical of Worthington for 118 years. Foremost examples of this leadership and engineering skill are the exclusive design advantages of Worthington pumps and compressors. Three of the most important are illustrated at left: Feather Valves*, Monobloc Rotary pumps, and the unmatched flexibility achieved through standardization of the SESC (Standard End Suction Centrifugal) line.

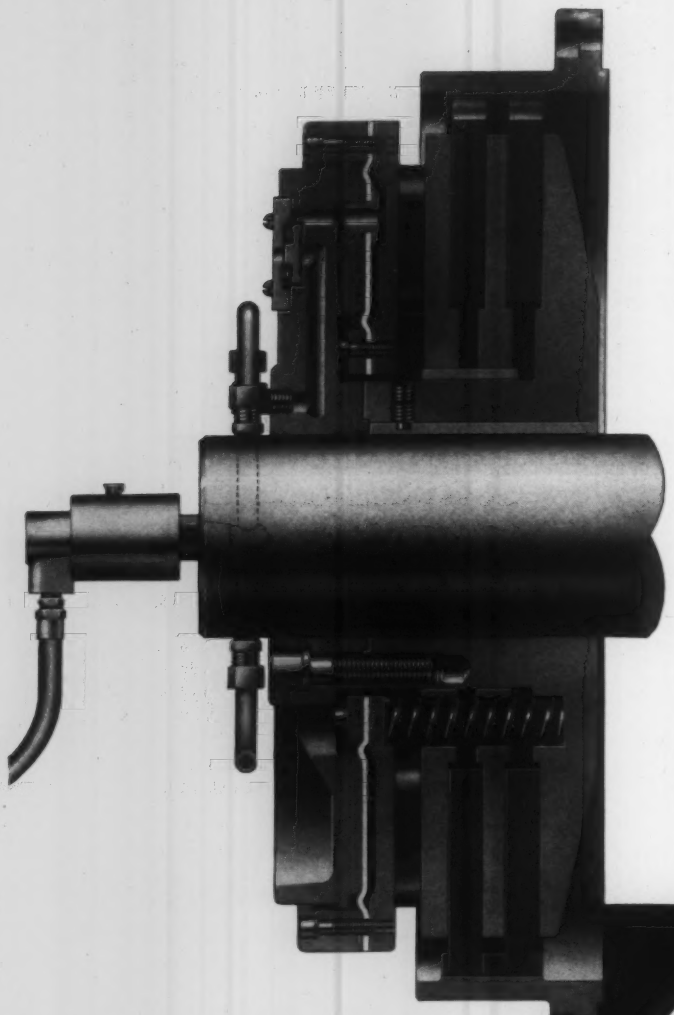
Worthite*, Worthington's *super* stainless steel, has set new corrosion resistance standards for chemical pumps. Worthington air-cooled or water-cooled compressors include carefully balanced operating parts, low piston speeds, and liberal cooling surfaces on cylinders and intercoolers or aftercoolers. Increased performance and accessibility of portable and balanced angle compressors and the money-saving benefits of easy installation and low maintenance of the entire pump and compressor line lend further testimony to Worthington engineering competence. But whatever your application, your design problem, Worthington can help you.

Your nearby Worthington representative stands ready to explain the many advantages of one *complete* Worthington pump and compressor line to you. For more information on how to improve your product's performance or reduce engineering design and expense, contact him now. Or write for bulletin, Worthington Corporation, Section 104-7, Harrison, N.J. In Canada, Worthington, Ltd., Brantford, Ontario.

WORTHINGTON

*A high-nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U.S. Pat. Off.

Circle 460 on Page 19



1. Quickest acting, most responsive air clutch available!
2. Finger tip control!
3. Built-in quick release valves! (Optional)
4. Requires minimum volume of air!
5. No adjustment necessary!
6. Internally ventilated — cooler operation!
7. Operates at air pressures up to 140 psi!
8. Most compact!
9. Interchanges with and can be used to replace Dodge or other mechanical clutches in existing installations.
10. Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.

AIR-GRIP

NEWER! BETTER!

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER —your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone book for "Dodge Transmissioneer."

This air clutch, engineered to modern needs, provides maximum torque capacity in minimum space. Its operation requires less air, resulting in amazing sensitivity. It gives the operator split-second control—from "inching" to full engagement. Quick-release valves are built into the clutch itself, as optional equipment, for instant disengagement where such service is required.

The unique design of Air-Grip places the air seal disc at the end *farthest* from the pressure plates, which generate the heat inherent in clutch action. This combined with automatic internal ventilation, insures cooler operation and longer life under severest service. Call your local Dodge Distributor, or write for Bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union Street, Mishawaka, Indiana

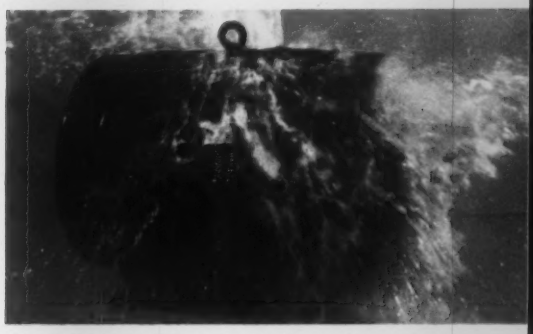
Circle 461 on Page 19

Circle 462 on Page 19→

YOU GET
DOUBLE PROTECTION
against corrosion...
against falling
or splashing liquids

Air intakes and outlets are positioned to provide complete dripproof protection.

TYPE DP
1 to 125 hp



DOUBLY PROTECTED—Wagner DP Motors offer the *double protection* of completely dripproof enclosures and rugged cast iron frames that can take rough handling and resist corrosion.

with WAGNER TYPE DP MOTORS designed to meet more application needs

Wagner Type DP Motors offer the *double protection* of rugged corrosion-resistant cast iron frames and dripproof enclosures so well designed that the DP Motor can handle many applications that formerly required splashproof motors.

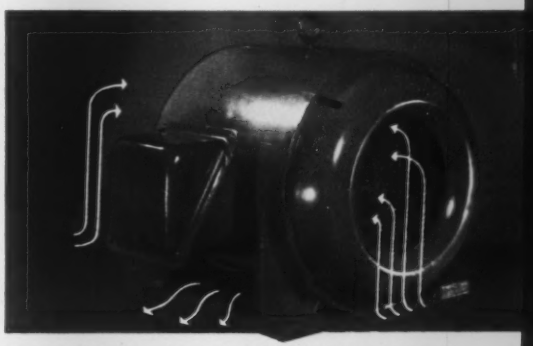
These Wagner Motors are built in the new NEMA ratings that pack more power in less space, are lighter in weight and are easier to maintain.

CAN BE RELUBRICATED—Factory lubrication will last for many years in normal service—but openings are provided to permit the relubrication that adds years to motor life under severe conditions.

SLEEVE BEARING MODELS AVAILABLE

The entire line of ratings through 125 hp is available with ball bearing construction as illustrated, or with steel-backed, babbitt lined sleeve bearings that have high load carrying capacity and provide quieter operation.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Wagner Bulletin MU-223.



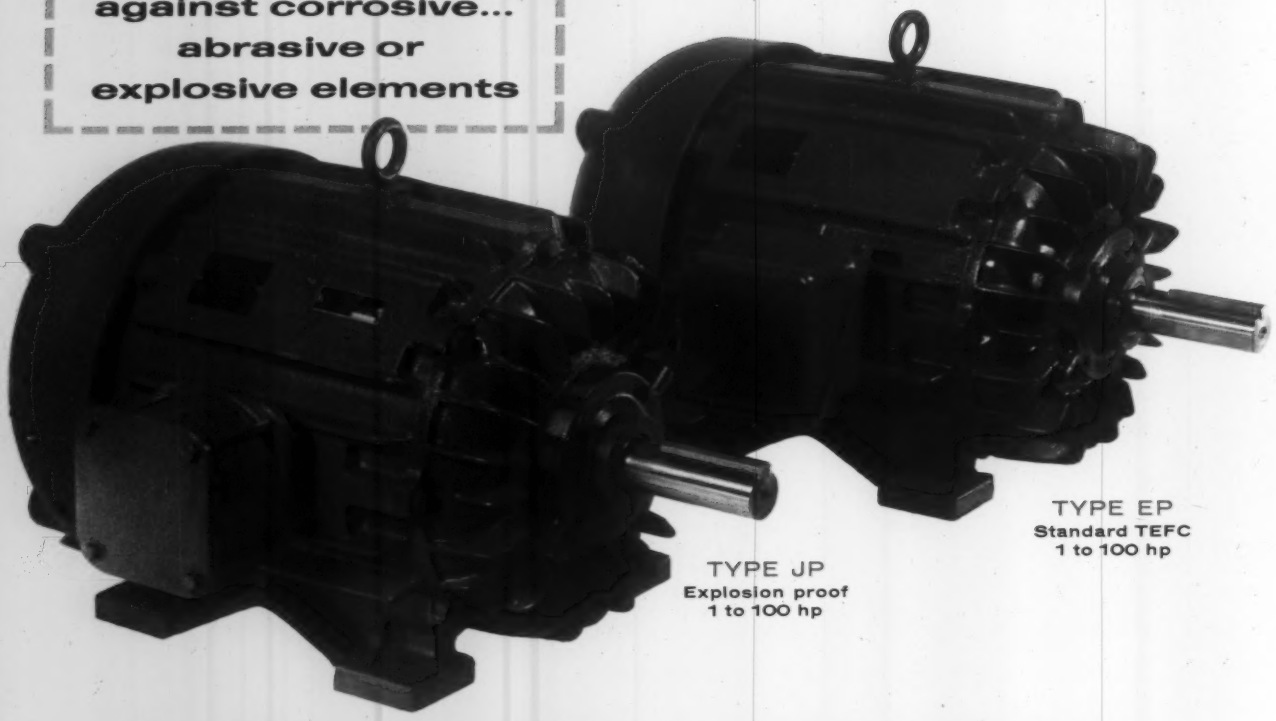
COOL RUNNING—Specially designed baffles direct cooling air through the motor to reduce stator temperature—thus increasing motor life. Blowers, cast as part of the rotor, move large volumes of air without noise or vibration.

1 to 125 HP—1750 RPM—40°C
NEMA FRAMES 182 through 445U

Wagner Electric Corporation
6400 Plymouth Ave., St. Louis 14, Missouri.

WM58-9

YOU GET
EXTRA PROTECTION
against corrosive... abrasive or explosive elements



TYPE JP
Explosion proof
1 to 100 hp

TYPE EP
Standard TEFC
1 to 100 hp

with Wagner totally enclosed motors... protected for longer motor life

If you need motors that will keep production rates up... that will give the continuity of service that is so important to automation... that will operate with complete dependability under the most severe conditions —Wagner totally-enclosed motors are your soundest choice.

Type EP Motors offer protection against corrosion, dust, abrasives, fumes, steel chips or filings. Type JP is explosion proof as well — designed and approved for use in explosive atmospheres.

NEW NEMA FRAMES—These motors are built in the new NEMA Frame sizes from 182 through 445U, with ribs that add mechanical strength and increase the surface cooling area. Effective cooling system adds to motor life.

Let your Wagner Sales Engineer show you how these protected motors can bring you savings on initial motor costs, maintenance costs and continuity of operation.

1 TO 100 HORSEPOWER—4 POLE, 60 CYCLE—NEMA FRAMES 182 THROUGH 445U

Wagner Electric Corporation

6400 Plymouth Ave., St. Louis 14, Missouri. Branches and Distributors in All Principal Cities

HEAVY DUTY BALL BEARINGS

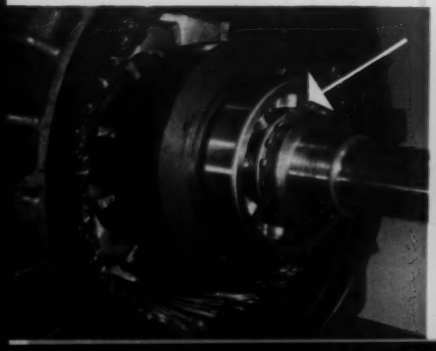
The ball bearings used in these motors are of the highest quality, with more than ample capacity to provide long troublefree service under heavy loads.

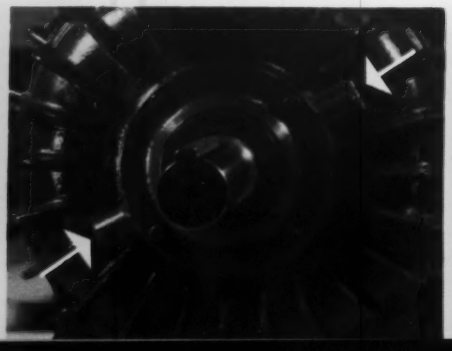
BEARINGS CAN BE RELUBRICATED

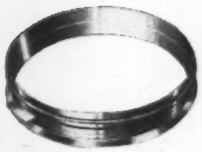
Factory lubrication will last for many years under normal service, but openings are provided to permit relubrication that adds years to motor life under severe conditions.

SEALS KEEP BEARINGS CLEAN

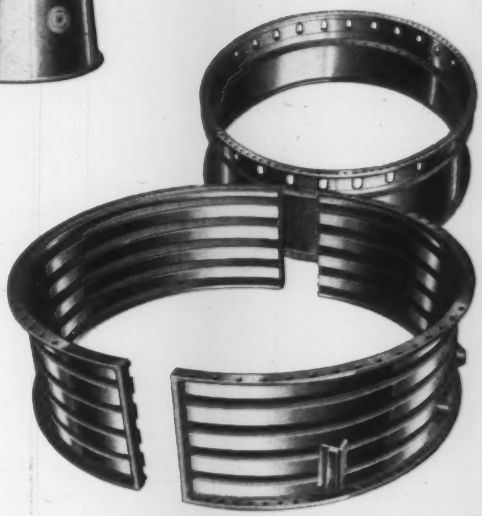
Both ends of these motors have running shaft seals to keep the bearings clean. Bearing housings are effectively sealed to prevent escape of grease.



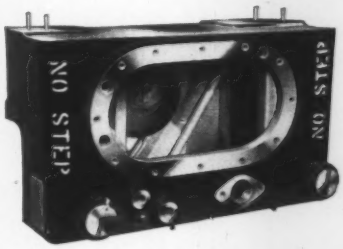




Looking for a Fabricating Source...



of welded precision assemblies?



As a major producer of circular parts and welded components for the aircraft industry, Amweld® possesses special knowledge and techniques for forming, welding, and machining of assemblies. Fabricating of aluminum, titanium, stainless, and heat-resistant alloys is a major part of this work. Experienced metallurgical and engineering staffs, plus a skilled work force, make up this team of fabricating specialists which is available to you on a subcontracting or experimental work basis.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you—phone or write today. Our local representative will be happy to call and discuss your requirements.

THE AMERICAN WELDING & MANUFACTURING CO.
130 Dietz Road • Warren, Ohio

AMERICAN WELDING

Write for complete information.
NEW 20-page catalog of Amweld Rings, Bands, and Welded Assemblies.
NEW booklet entitled, "HOW AMWELD FLASH BUTT-WELDED RINGS ARE PRODUCED."

Circle 463 on Page 19

For Rolls... Specify

Versatile ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

Among the equipment Blaw-Knox Company manufactures for many industries are steel mill roll-out tables. ACIPCO tubes, furnished as cast, 12.43" OD x 9.50" ID, machine cut to 4-ft. lengths, are used as rolls in this Blaw-Knox table.

Because they are centrifugally spun, ACIPCO tubes are dimensionally stable and possess an inherent high degree of dynamic balance. Their dense, homogeneous, inclusion-free grain structure results in good machinability. In addition, ACIPCO tubes are highly resistant to impact, an important requirement for steel mill table rolls.

These advantages, plus the flexibility of ACIPCO's complete "one source—from start to finish" facilities, are reasons why Blaw-Knox specified ACIPCO centrifugally spun tubes for this application.

"Custom-spun" in stainless steel, all carbon steels or special analyses as well as in all alloy irons including Ductile, ACIPCO tubes are furnished to your exact physical, chemical and metallurgical specifications.

If rolls are a part of your products, or if you use tubular metal components in any way, get full information about ACIPCO. Call or write today.

BLAW-KNOX

One of the world's leading producers of complete mills and auxiliary equipment for rolling ferrous and nonferrous metals, Blaw-Knox Company also is a major supplier to the chemical, petroleum, food processing, construction and communications industries. The company has its headquarters in Pittsburgh, and manufacturing plants in Pittsburgh and Erie, Pa., Buffalo, Chicago, Mora, Minn., and Wheeling, W. Va.

VERSATILE ACIPCO TUBES

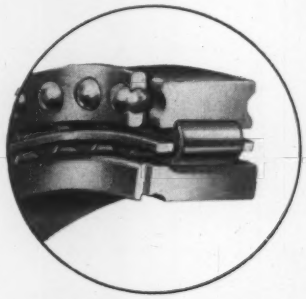
Size Range: Lengths up to 410" have been produced to meet modern machinery requirements. OD's from 2.25" to 50"; wall thicknesses from .25" to 4".

Analyses: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

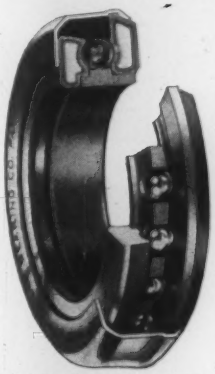
Furnished: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION
AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

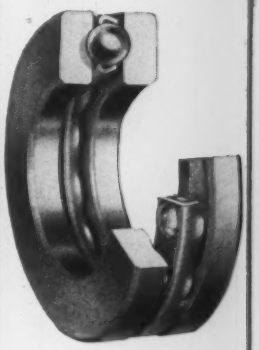
ACIPCO



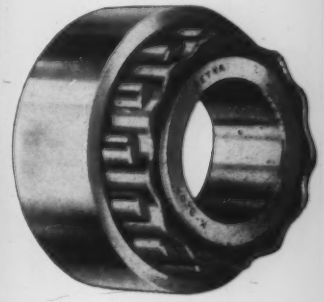
COMBINATION ROLLER AND BALL BEARING



CLUTCH RELEASE BEARING



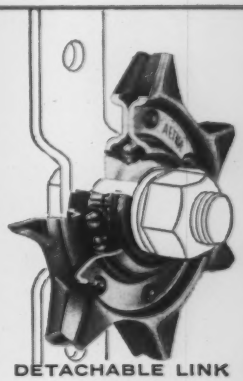
THRUST BEARING



ROLLER BEARING

STANDARD SPROCKET IDLER UNIT

Aetna "Firsts"



DETACHABLE LINK IDLER UNIT

Aetna engineers have that inquiring type of mind which is constantly seeking—constantly asking itself questions—constantly developing new and better ways of doing things.

This creative engineering approach has resulted in an imposing record of Aetna "firsts".

1st to combine cylindrical roller and ball thrust in a single bearing to divorce the load into pure radial and pure thrust for extremely heavy duty service

1st in sales of clutch release bearings for mobile on-and-off the road vehicles—first for more than a quarter-century

1st with a complete line of precision-built thrust bearings to meet practically every load, speed and application requirement

1st to standardize on true crown rollers for all roller bearings to secure the best load distribution of load stresses for far longer service life—permanently assembled in retainers of a type which maintains alignment and correct spacing

1st to combine a roller chain sprocket idler and pre-lubricated ball bearings in a single, compact, easy-to-install single package unit

1st ball bearing detachable link sprocket idler with a full complement of ball bearings, self-contouring seals and sturdy sprocket wheel

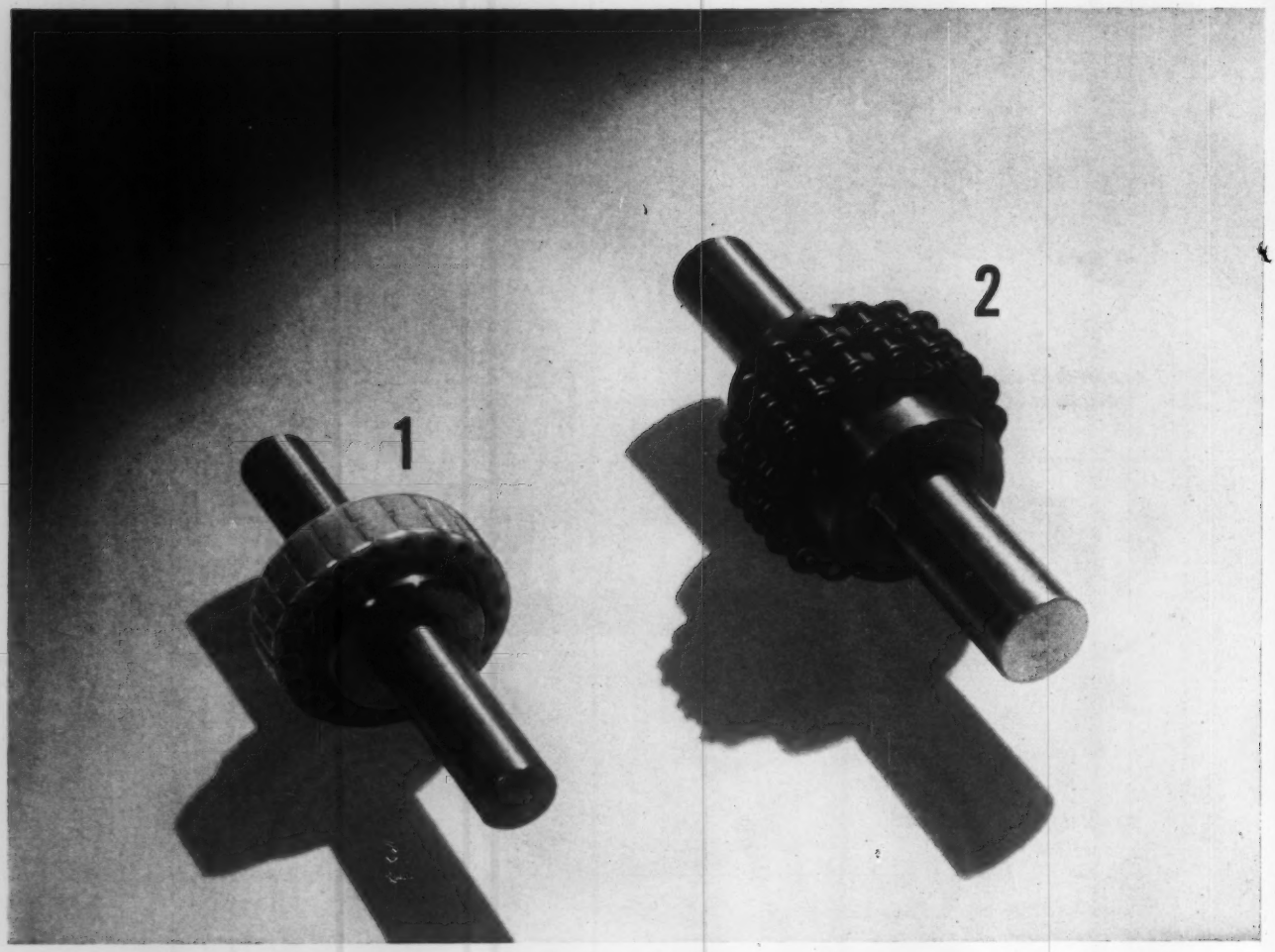
Take advantage of this creative engineering talent and Aetna's diversified production facilities. Call your local representative listed in the yellow pages of your Classified Phone Book, or write direct for New 15th Edition Catalog and Engineering Manual.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

Aetna ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

Circle 465 on Page 19



Morse's new Nylon Coupling means:

Nobody can answer your coupling because only Morse offers

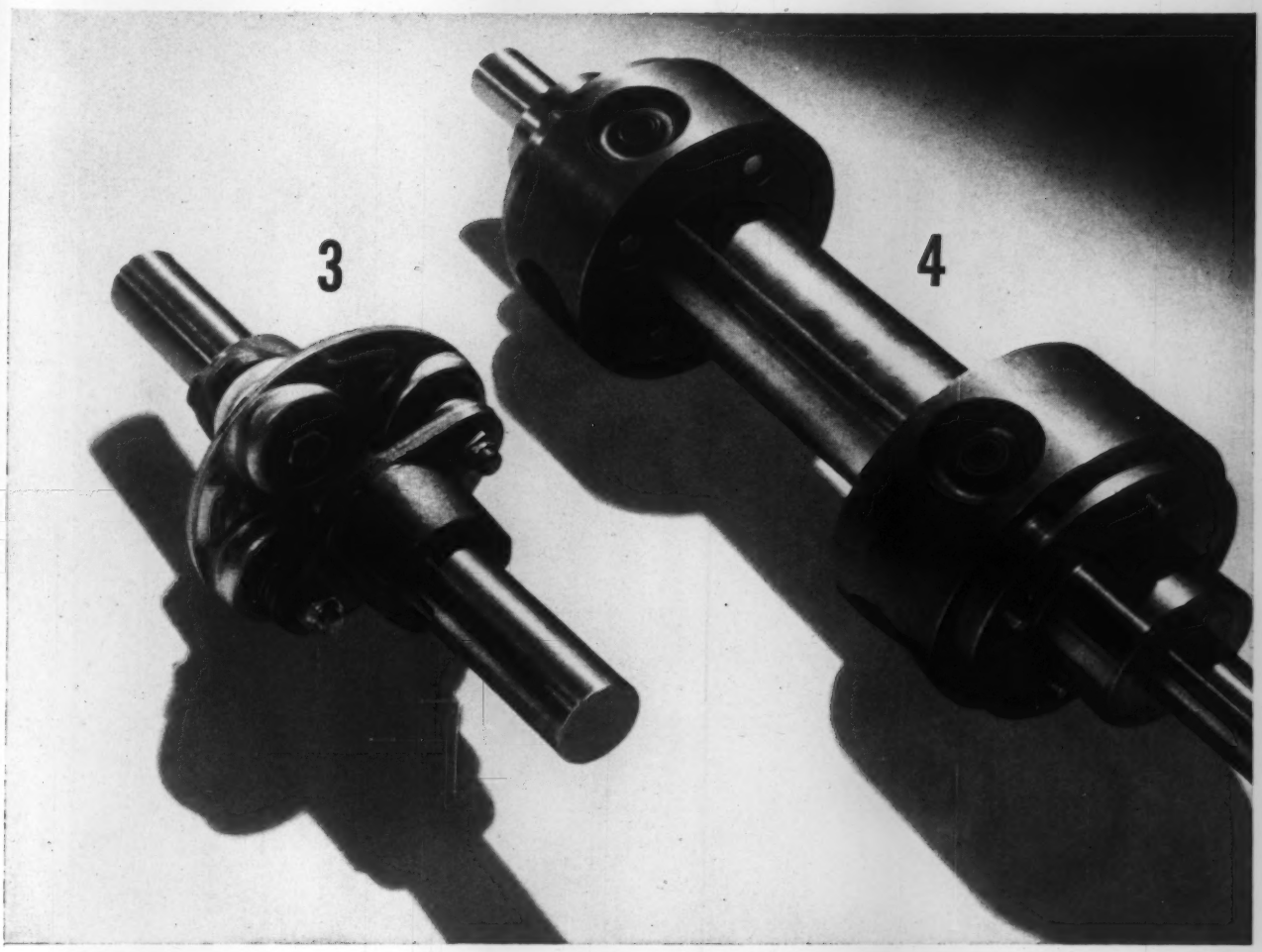
1 New Nylon Couplings:
Cost 20% less than conventional couplings; last indefinitely. Need no lubrication, no cover; take high torque; adjust to misalignment.

2 Flexible Chain Couplings:
For moderate speeds, steady loads. Rugged, economical . . . take higher h.p. per given diameter. Easy to install, align, and disassemble.

3 Morflex Couplings:
Preloaded neoprene biscuit assembly reduces misalignment stresses, increases bearing life; protects machine from shock and vibration.

4 Radial Couplings:
Neoprene biscuits—assembled radially on pins—take heavy thrusts, torques, shocks, frequent load reversals; retain torsional flexibility.

NOTE: All Morse couplings are available in driveshaft constructions.



problems as well as Morse, all four of these flexible couplings

REMEMBER: Nobody gives you a more *impartial* analysis of your power transmission problems than Morse, because *only Morse* offers all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belt Drives . . . plus a complete line of power transmission products.

IN POWER TRANSMISSION THE TOUGH JOBS COME TO

MORSE BW BORG-WARNER*

*Trademark

MORSE CHAIN COMPANY, Dept. 6-98, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Illinois

Tubexperience in action

How does carbon content control hydraulic tubing quality?

Precise metallurgical controls help Superior's (SAE) Hydraulic Tubing outperform all other types

*Extra quality is the reason for the high ductility and longer, more reliable service you get with Superior hydraulic tubing. This extra quality is actually built in through precise metallurgical control.

Carbon content is held to .12% maximum through controlled atmosphere annealing. This assures highest ductility commensurate with the strength needed in the tubing.

Superior (SAE) Hydraulic Tubing is made from selected billets of non-aging steel. These are segregated by heat numbers, and a customer's order is always filled from one heat. This assures complete uniformity of all the tubing shipped to him in that order.

Each order also undergoes many critical examinations. Among these are checks on elongation, yield and ultimate strength. Every length is also 100% hydrostatically tested to maximum working pressure. And close control is exercised over grain size and microstructure. This is done microscopically with the aid of metallographic mounts. And finally, if requested, we furnish a notarized report on the chemical and physical properties of the tubing produced.

Superior (SAE) Hydraulic Tubing is furnished in dead-soft annealed temper for easy bending and flaring. Order in cut, multiple or random straight lengths up to 30 ft.—or longer in coiled form.

For more data on our (SAE) hydraulic tubing, get a free copy of Bulletin 39. Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

X-ray photo shows a typical use of Du Pont TEFLON TFE resins as seals in hydraulic power cylinder

Here's why seals of TFE-fluorocarbon resins may be your solution

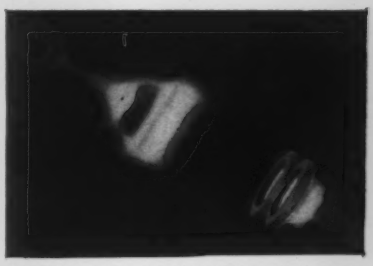
Seals of TFE-fluorocarbon resins give outstanding protection against leakage; they reduce maintenance costs, improve SAFETY and RELIABILITY. The reasons are many—

TFE resins are among the most chemically inert materials known to science. They are rated for continuous use at temperatures from -450°F. to 500°F. and have the lowest coefficient of static friction of any solid substance known.

The low surface friction of seals of TFE resins makes for reduced torque and easy operation. As in the hydraulic cylinder shown above, these seals reduce oil leakage, will not stick or freeze, require no adjustment and are shearproof. Seals of TFE resins are available in all basic designs and configurations.

Discover how you can improve your products and processes with seals of Du Pont TFE-fluorocarbon resins. For product and design information see your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room MD2524, Nemours Building, Wilmington 98, Delaware.**

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.



PISTON RINGS of a filled TFE resin in control cylinder help throttle a fiery jet engine. Rings operate without lubrication . . . handle corrosive hydraulic fluids at 350°F. and 3000 psi for over 300 hours without wear.

DU PONT
REG. U.S. PAT. OFF.

TEFLON®
TFE-FLUOROCARBON RESINS

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

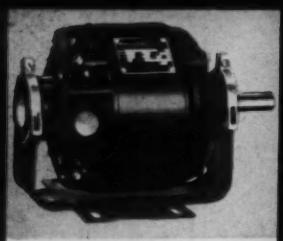
Circle 468 on Page 19

Here Production Counts...

For eggs, there is no finer production facility than a hen. And, for production facilities unrivaled in the appliance and equipment motor field, look to Emerson-Electric.

Remember . . .

- Emerson-Electric's unique production facilities assure you *on-time* deliveries.
- We produce *custom-engineered* motors to suit *your specific needs.*



Put more than 65 years of experience to work for you. Call, wire or write Dept. M-330 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

EMERSON-ELECTRIC *of St. Louis · Since 1890*

Circle 469 on Page 19

Tailor-made, tough and chemically inert...

. . . these J-M Chempac Teflon components combat chemical and solvent action!*

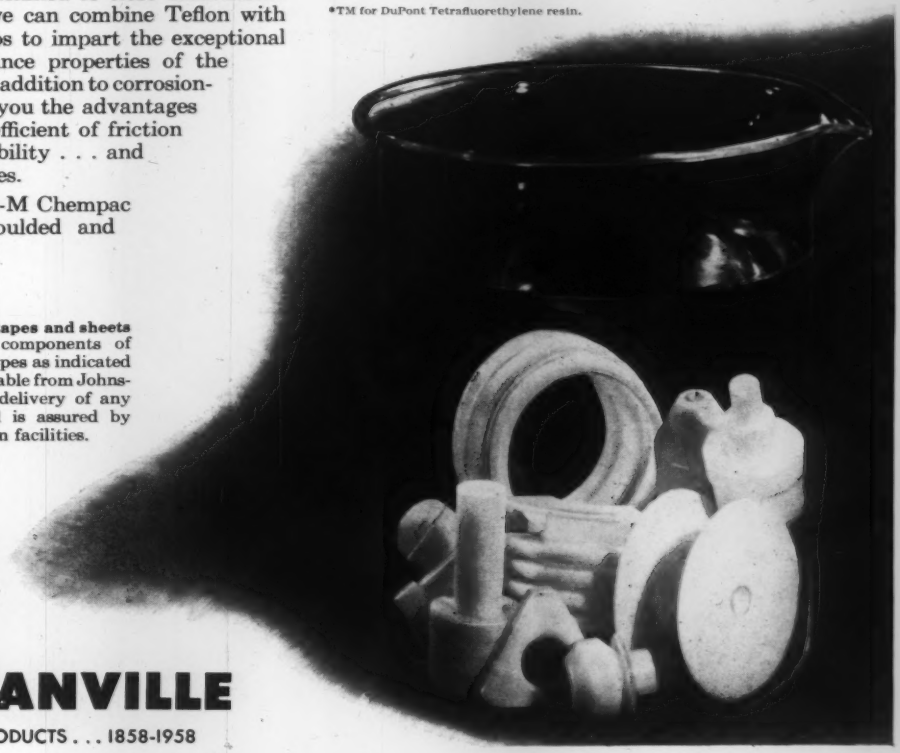
SMALL OR LARGE . . . intricate or simple . . . J-M Chempac® Teflon components have proved their exceptional resistance to the constant attack of corrosive chemicals in rugged service.

Look to J-M for Teflon packings, gaskets, and moulded shapes made to your exact specifications . . . or for parts that are machined to close dimensional tolerances. Moreover, we can combine Teflon with top quality J-M asbestos to impart the exceptional sealing and heat-resistance properties of the "magic mineral." And in addition to corrosion-resistance, Teflon gives you the advantages of an extremely low coefficient of friction . . . toughness and flexibility . . . and weight-saving possibilities.

You can also obtain J-M Chempac Teflon Packings in moulded and braided types for pumps and valves . . . in a wide range of flange and envelope-type gaskets . . . in rings, cups, sheets and tapes. Your J-M Packings Distributor can supply your needs. Or write Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario.

*TM for DuPont Tetrafluorethylene resin.

Teflon rods, tubes, tapes and sheets —in addition to components of varied sizes and shapes as indicated here—are also available from Johns-Manville. Prompt delivery of any quantity you need is assured by new J-M production facilities.



JOHNS-MANVILLE JM PRODUCTS

JOHNS-MANVILLE

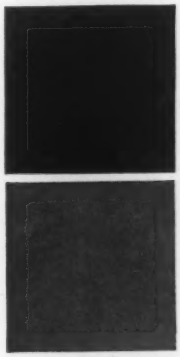
100 YEARS OF QUALITY PRODUCTS . . . 1858-1958

TOTAL COVERAGE

Torrington offers the most complete line of fans in the United States. Applications range from small precision fans for electronic cooling to the largest heavy-duty requirements of industrial and residential air moving—in diameters from 1½″ to 52″.

Torrington blower wheels are available in diameters from 1½″ to 16″. A full range of designs includes standard single and double inlet Airotors, in both continuous and individually-bladed construction.

In complete blower units, Torrington offers proved-out performance ratings on three full lines, the Vari-Basic line of belt driven and direct drive units, plus the revolutionary new mixed flow Radiax blower.



The result is TOTAL COVERAGE—the best "problem insurance" you could have. For complete data:

Talk to Torrington!

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

Circle 471 on Page 19

Take a New Look at

TITANIUM

Wonder metal? Restricted supply? Not today. Titanium is daily *proving* its economic advantages in more and more industrial applications.

And Mallory-Sharon... world's largest integrated producer of special metals... is ready *now* to assist you in designing with titanium. We can supply your requirements for titanium and titanium alloy sheet, strip, rod, bar, plate and other mill products... many of them from stock.

Check below for ways titanium and its alloys can serve you now! Then write us about your requirements, or contact our nearest sales office.

For availability – *Delivery time on titanium has been cut by Mallory-Sharon's ingot inventory in certain grades and analyses. Here, orders can be started in the ingot stage, saving time for fabricators. In addition, a wide range of sheet and bar sizes can be shipped direct from stock.*

For corrosion resistance—*Turbine impeller made from titanium has given four years' service in highly corrosive application that killed other metals in weeks or even hours. Impeller agitates slurry containing cobalt, nickel, copper arsenic, iron and sulfuric acid.*

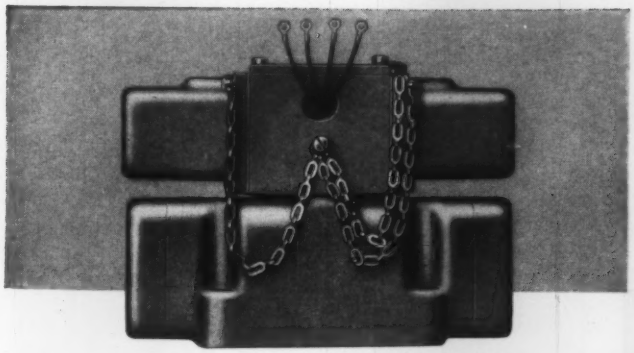
For high strength-to-weight—*In the U.S. Air Force's B-58 Hustler, built by Convair, Fort Worth, heat-treated titanium alloy was substituted for alloy steel—for wing fittings bearing heavy loads. Result: 44% saving in weight, with strength equal or superior to the previous material.*

For technical facts *write for "Titanium Fact File"—giving advantages, metallurgy, corrosion properties, information on machining, welding, forming. Our Service Engineering group is ready to assist you.*

MALLORY SHARON

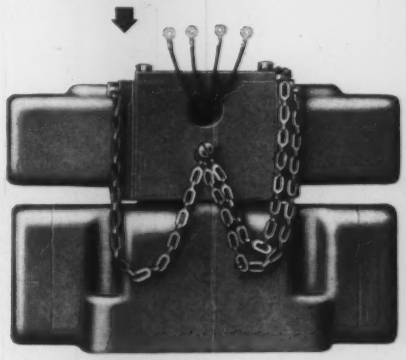
MALLORY-SHARON METALS CORPORATION · NILES, OHIO

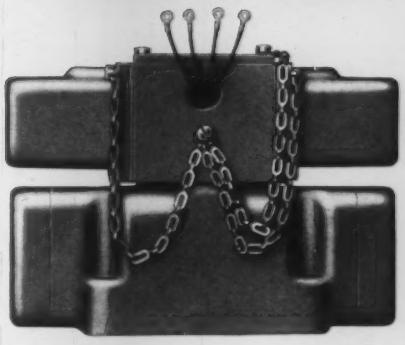
Integrated producer of Titanium • Zirconium • Special Metals



A LOGAN HYDRAULIC CONTROL VALVE

2 competitors' control valves





do they LOOK ALIKE? ...sure they do on the surface...

...BUT LOOK AT Logan's BIG EXTRA PLUS VALUES

Logan Hydraulic Control Valves

are made to interchange with other leading manufacturers' control valves . . .

1. Logan designs assure the service required for those extra-rugged applications.
2. Over FORTY YEARS of fluid power components manufacturing know-how.
3. Built by CRAFTSMEN whose average service record with LOGAN is more than 20 years.
4. Manufactured in a plant which applies the most modern production methods.

FREE

SEND FOR THE "LOGAN CALCULATOR"

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-6 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
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- ☐ 200-2 ROTOCAST HYD. CYLINDERS
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- ☐ 200-4 AND 200-7 HYD. VALVES
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TO.

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COMPANY _____

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WHEN THE GAP NARROWS...

TRY IPC THIN SEALS

In a limited space application the *seal has to be good. Both* pressure and temperature can demand more from your seal when the opening is smaller . . . less room means the seal itself has to be made to closer tolerances . . . and it must stand up after repeated usage.

IPC "thin seals" combine the ultimate in custom compounds with the finest steels. Add IPC's bonding experience — and both compound and case are permanently joined. Result? . . . better service than can be found with other types of thin seals.

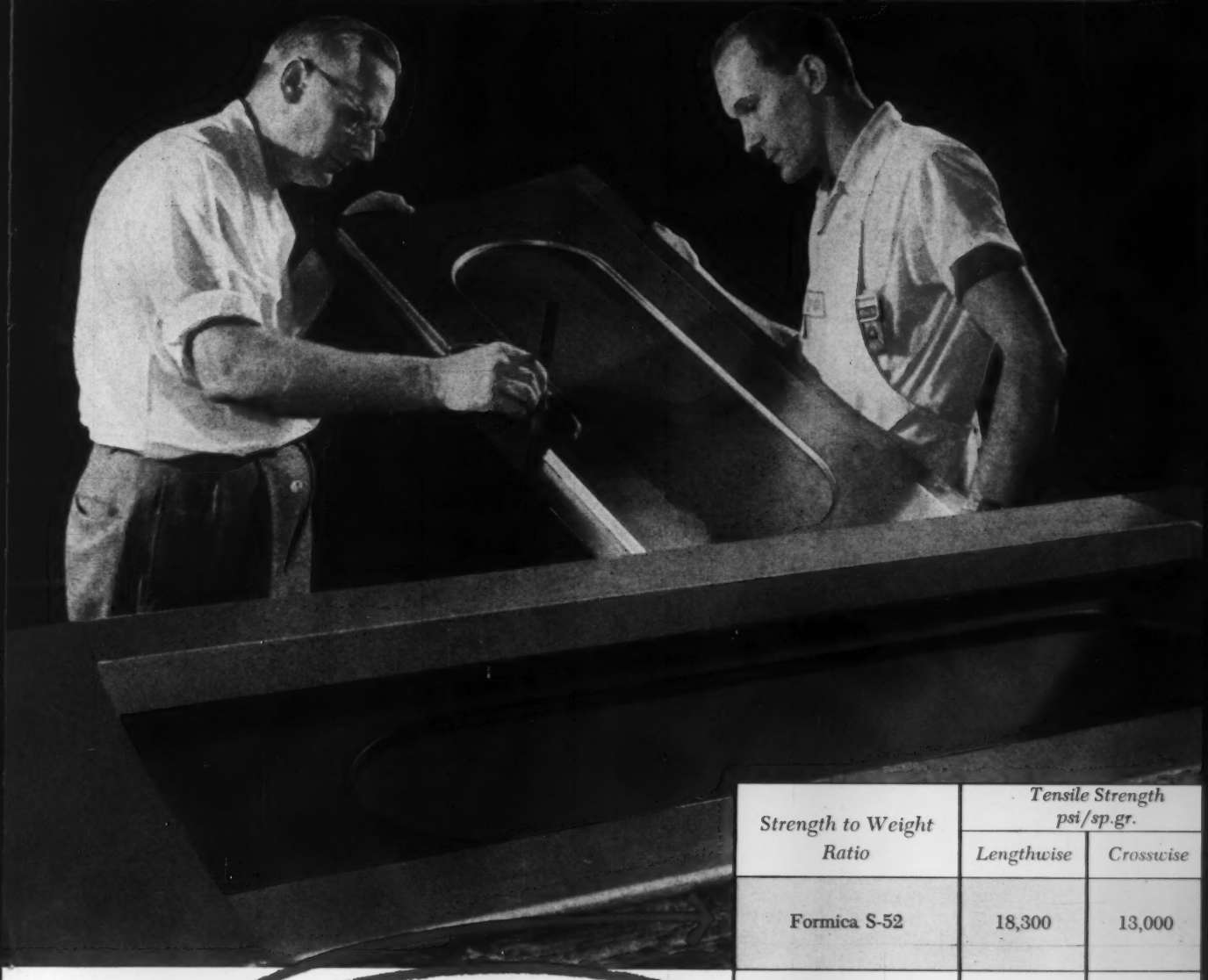
Remember . . . when the opening is closing . . . your IPC engineer will be happy to help you solve your sealing problem. Why not tell us your trouble spots, today?

IPC

OIL SEALS / O-RINGS / PACKINGS

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire P5

What! Formica laminated plastic stronger than steel?



Strength to Weight Ratio	Tensile Strength psi/sp.gr.	
	Lengthwise	Crosswise
Formica S-52	18,300	13,000
SAE 1020 Steel	10,000	10,000

It's a fact! Here's the proof

Unique strength/weight ratio makes Formica S-52 the most efficient and economical material for tooling and metal-forming applications. Strong, hard, dent resistant properties mean longer production runs. Light weight (half that of aluminum) means more metal-forming surface per dollar. Plus faster tool delivery (S-52 matched dies above were made in 4 weeks compared with 4 months when made of steel).

Where great strength, light weight and long wearing properties are required, for structural and wear-resistant applications, S-52 and other Formica grades stand the test of time. Complete technical data contained in S-52 bulletin 872 and general catalog 829. Write for your free copies, or phone your nearest Formica Sales-Service office.

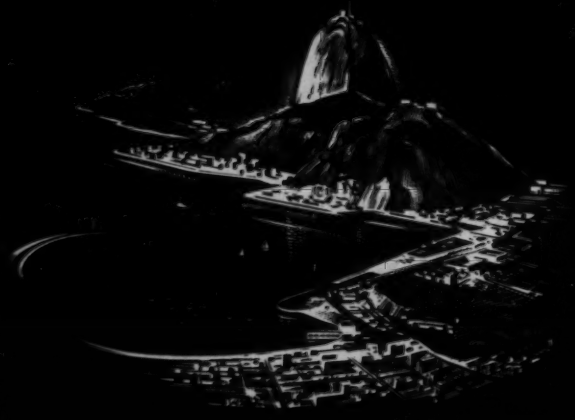
Formica Corporation, subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.

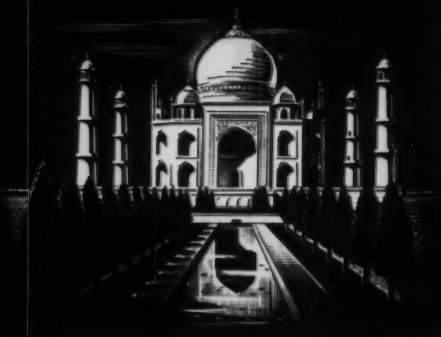
a product of CYANAMID

FORMICA
Laminated Plastic

Circle 475 on Page 19

No matter where your customers buy Macoma





Other Outstanding Shell Industrial Lubricants

Shell Tellus Oils—for closed hydraulic systems

Shell Alvania Grease—multi-purpose industrial grease

Shell Turbo Oils—for utility, industrial and marine turbines

Shell Rimula Oils—for heavy-duty diesel engines

Shell Talona R Oil 40—anti-wear crankcase oil for diesel locomotives

Shell Dromus Oils—soluble cutting oils for high-production metal working

Shell Voluta Oils—for high-speed quenching with maximum stability

Its performance and name are the same around the world

Shell Macoma Oils are premium quality, fortified extreme pressure gear oils. They provide superior high-load-carrying capacity and are particularly effective where overloading, severe shock-loading or general heavy-duty conditions exist.

Macoma* Oils have these added built-in benefits: excellent resistance to oxidation, great adhesiveness, rapid separation from water. They are non-corrosive, non-foaming and have high stability in storage.

The world-wide availability of Macoma Oils is assurance that your customers abroad will get the same performance from your equipment that your domestic customers rely upon. For complete specifications, write Shell Oil Company, 50 West 50th St., New York 20, N. Y. or 100 Bush St., San Francisco 6, California.

*Registered Trademark

SHELL MACOMA OIL

SHELL

Circle 476 on Page 19

Circle 477 on Page 19→

d'Arazien

Alcoa puts the metal where you want it

Before you read on, blink your eyes. In the time it took to do that, this man has produced an entire automotive grease gun body—complete with external ribs; solid end; smooth, seamless interior; and go-to-market external finish.

Sound too easy? No! We can make round, oval, square and irregular parts the same way. Finished parts—with the strength of forgings—with tolerances down to plus or minus 0.005″—with a smooth, corrosion-resistant finish of about 125 microinches. A clear case of putting the metal where *you* want it. The cost of tooling for impacts is surprisingly low, too. A good rule to remember is that virtually any closed end or tubular design should be considered as an Alcoa® Impact.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean fewer rejects or ingenious design solutions . . . less waste in production or a product that sells faster. Start now; write for Alcoa Up-to-Daters, a file of design tips on Alcoa Engineered Products. Aluminum Company of America, 1999 Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

Alcoa puts the metal where you want it — in castings, forgings, extrusions, screw machine parts and impacts.

ALCOA THEATRE
FINE ENTERTAINMENT
ALTERNATE MONDAY EVENINGS

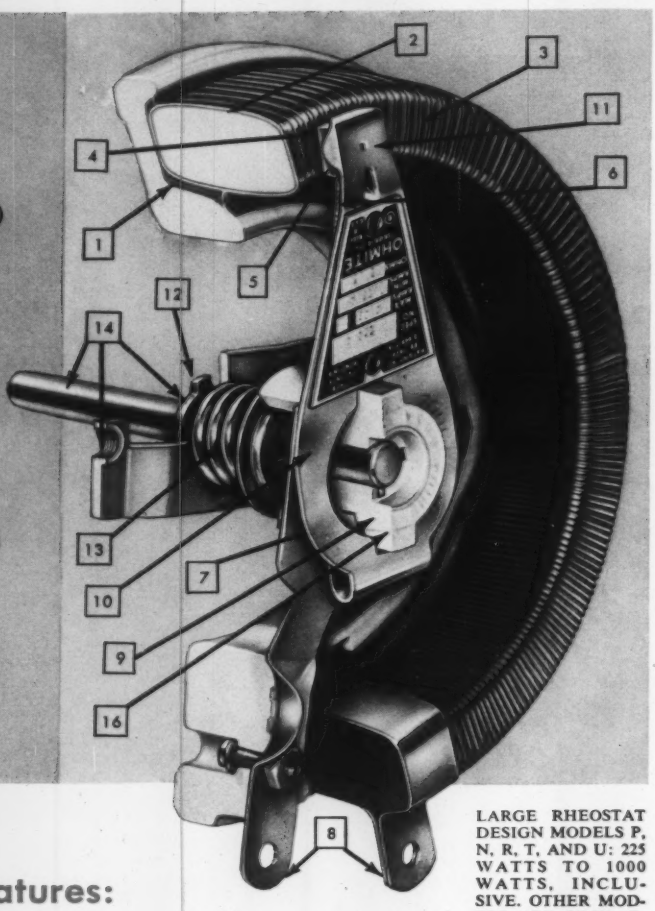
Smooth Close Control

OHMITE®

RHEOSTATS

NOW 11 Sizes! 12½ to 1000 Watts

Ohmite offers you industry's most complete line of rheostats. All sizes are available from stock in a wide range of resistance values, including the NEW Model "E." Ten sizes are available to meet MIL-R-22A requirements in *each* of the 26 type designations.



LARGE RHEOSTAT DESIGN MODELS P, N, R, T, AND U: 225 WATTS TO 1000 WATTS, INCLUSIVE. OTHER MODELS ARE SIMILAR.

16 Quality Engineering Features:

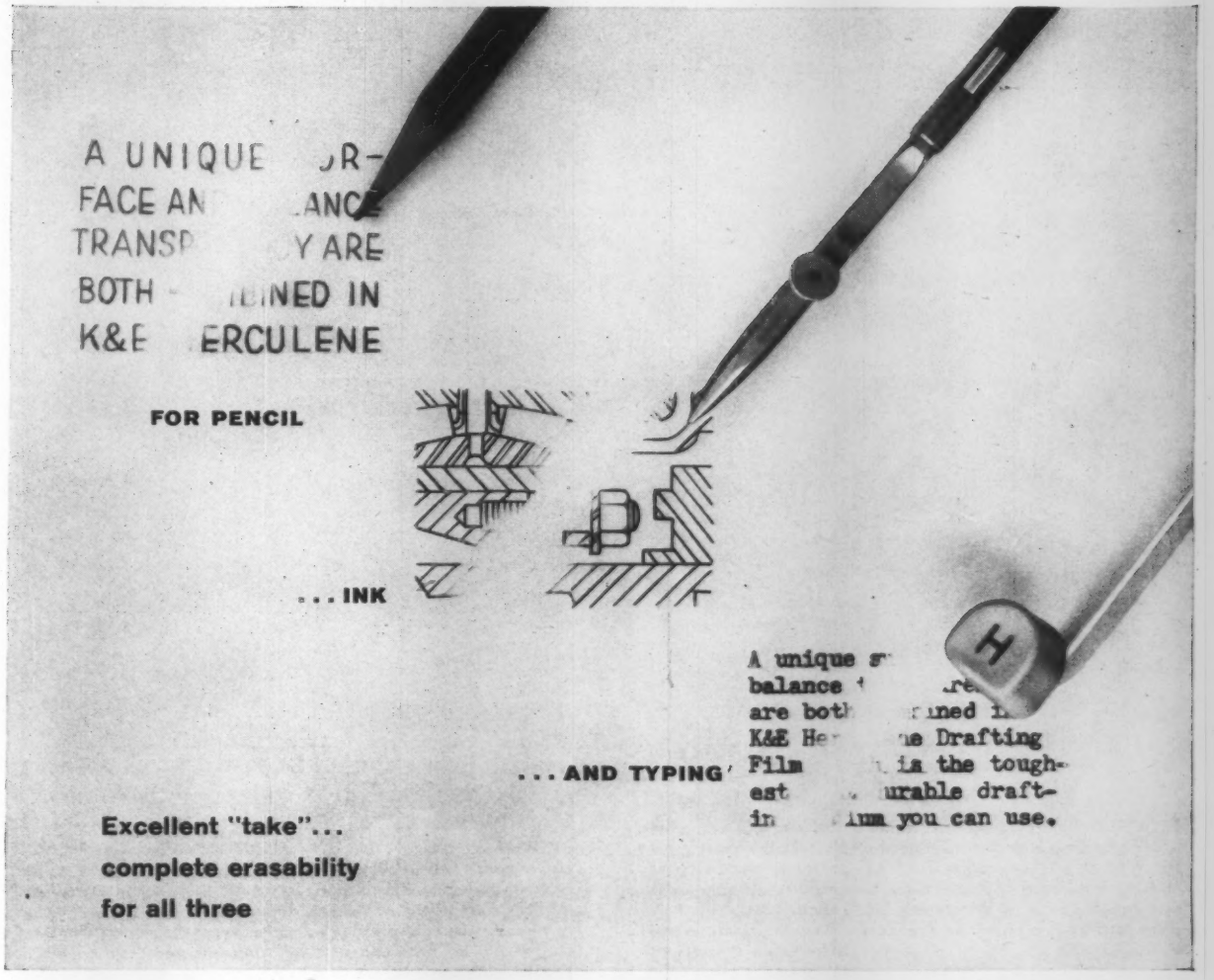
1. Vitreous enamel bonds the core and base together into one integral unit.
2. The wire is wound over a solid porcelain core, and each turn is locked against shifting by vitreous enamel. Uniform or tapered winding.
3. Close graduation of control. Each turn of wire is a separate resistance step.
4. Large, flat surface upon which the contact brush rides.
5. Metal-graphite contact brush (varied to fit current and resistance) insures good contact, with negligible wear on the resistance wire.
6. Shunt pigtail of ample size carries the current directly to the slip-ring.
7. Large slip-ring of high-current carrying ability minimizes mechanical wear and provides connection from the moving contact to the terminal.
8. Potentiometer use. The rheostats are provided with three terminals so they can be used as potentiometers or voltage dividers.
9. High strength ceramic hub insulates the shaft and bushings from all live parts. All sizes will stand a 3000 volt a-c breakdown test to ground.
10. The contact arm is a long tempered steel spring which assures uniform contact pressure at all times. Cadmium-plated for corrosion resistance.
11. Rounded pivot holds contact brush in flush-floating contact with wire.
12. Stops which are keyed to the shaft and base limit the rotation—thus no torsional strain is imposed on the contact arm on stopping.
13. Compression spring maintains uniform pressure and electrical contact between slip-ring and center lead at all times.
14. Models H, J, G, K, and L: Phosphor-bronze retaining ring takes end-thrust. Models P, N, R, T, and U: Stop washer takes end-thrust. Steel shaft in brass bushing provides a wear-resistant, wobble-free bearing.
15. Ohmite rheostats meet requirements of NEMA and EIA (formerly RETMA).
16. There are only ceramic and metal in the construction of Ohmite rheostats—there is nothing to char, burn, shrink, or deteriorate.

Write on company letterhead for Catalog 58.

BE RIGHT WITH OHMITE® QUALITY Components

OHMITE MANUFACTURING COMPANY
3618 Howard Street Skokie, Illinois

RHEOSTATS RESISTORS RELAYS
TAP SWITCHES TANTALUM CAPACITORS
R. F. CHOKES VARIABLE TRANSFORMERS



Now K&E provides the ultimate "3-way" surface for super-tough HERCULENE™ Drafting Film

Only K&E Herculene Drafting Film has a surface perfectly engineered for pencil, ink and typing . . . plus the extreme toughness and durability of a DuPont "Mylar®" film base. You get the absolute assurance of superior "take". And Herculene erases easily and quickly without the need for erasing or correcting fluids.

Virtually indestructible, Herculene is so tough you can hardly tear it. It can't be damaged by moisture. And it's permanent . . . your drawings are resistant to damage by aging or handling.

Herculene has "balanced" transparency . . . just the right combination of high actinic transparency for reproduction with essential visual opacity for drafting. You get sharp, legible reproductions at high machine speeds. And you can make prints from a Herculene Drawing indefinitely without its yellowing or tearing, cracking or becoming brittle.

Herculene is economical too . . . costs only a few cents more than cloth. Prove these facts for yourself by writing today for a free sample. Just clip and mail the coupon below.

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K+E

KEUFFEL & ESSER CO., Dept. MD-9, Hoboken, N. J.

I want to see a sample of the new K&E Herculene.

Name & Title: _____

Company & Address: _____

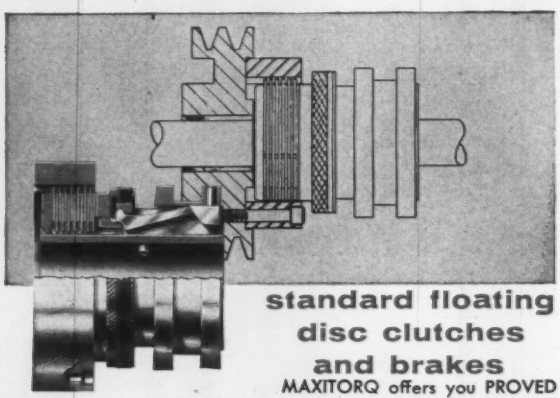
_____

Circle 479 on Page 19

if your design calls for CLUTCHES or BRAKES

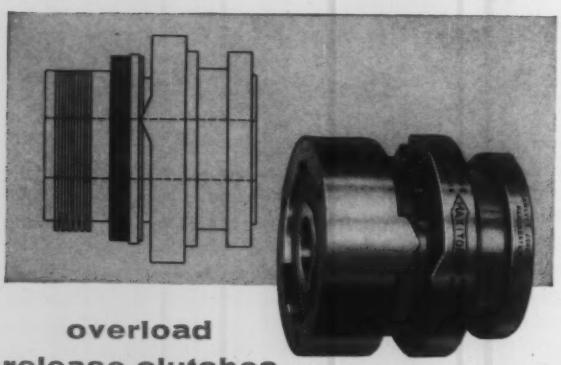
MAXITORQ electric clutches and brakes

PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Use easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V, A.C., rectified to 90 V, D.C. Other voltages on special order.



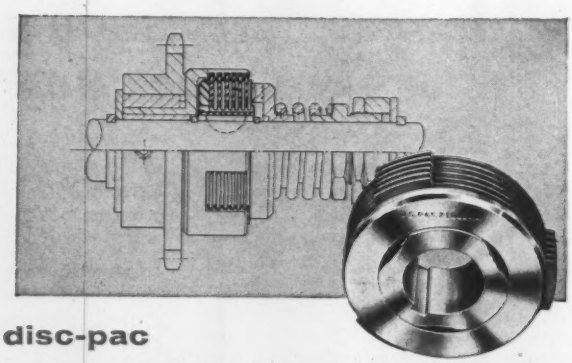
standard floating disc clutches and brakes

MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full power transmission . . . full range of sizes and types . . . supplied as complete, easily installed units.



overload release clutches

One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release on machines requiring this safety feature in addition to a clutch. Incorporate all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.



disc-pac

The "heart" of the SERVICE-PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

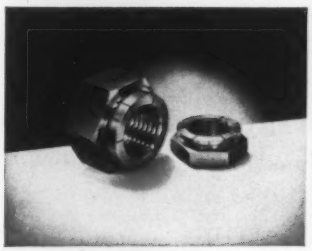
Write for complete data and specifications on any or all of the above. If you have a problem involving clutch applications, consult us. A letter or phone call will receive prompt attention. Dept. MD-9.

7CJ57RR

THE CARLYLE JOHNSON MACHINE COMPANY, MANCHESTER, CONN.

200-ton flying press, so called because of its unique rotary die action, fabricates coil steel on-the-fly, with dies and strip in continuous motion. Inset shows FLEXLOC self-locking nuts used in fastening die assembly. For maximum clearance, thin-type FLEXLOCS were selected for this particular application. Despite constant pounding and vibration, they never require retightening.

FLEXLOC self-locking nuts stay tight under constant pounding of heavy machinery



FLEXLOC self-locking nuts lock and stay locked wherever wrenching stops. Neither impact, shock nor vibration will work them loose. They help give your products greater reliability, a quality which industry and the public are demanding as never before.

You can specify FLEXLOCS in either regular height or thin height (for applications where space and weight savings are primary considerations). Both are 1-piece, self-locking units requiring no separate locking devices—no lockwashers, jam nuts or cotter pins. There is nothing to put together, come apart or get lost. And there are no nonmetallic inserts to weaken the structure of the nut. With a FLEXLOC, every thread, including those in the locking section, carries its full share of the tensile load.

Because they require no auxiliary locking elements, FLEXLOC self-locking nuts facilitate design and specification; simplify purchasing, inventory and handling; reduce assembly time and costs. They also save on maintenance by eliminating the nuisance of retightening nuts that have vibrated loose. Yet FLEXLOCS are readily removed when necessary and can be reused many times without loss of locking power.

See your authorized SPS distributor for complete details. He carries FLEXLOC self-locking nuts—regular and thin height—in a full range of standard sizes, materials and finishes. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

HIGH RELIABILITY

SPS research is continually developing fasteners with higher and higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase your overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

We also manufacture precision titanium fasteners / write for free booklet

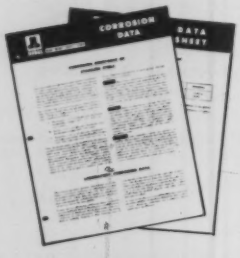
SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

New Sendzimir Mill

produces stainless steel sheets to extremely close tolerances in widths up to 48 inches

This new Sendzimir mill, complete with annealing, pickling, skin pass and other equipment, was designed and engineered for the exclusive production of the highest quality stainless sheet and strip. It is located at the Louisville, O., plant of J & L's Stainless and Strip Division. For complete information on the Division's flat rolled stainless products, write our Detroit sales office today.



Write for these Technical Data:
1. Laboratory Corrosion Data.
2. Data Sheets (please specify the grades in which you are interested).

Improve your Products with . . .
J&L STEEL STAINLESS
BAR • WIRE • SHEET • STRIP

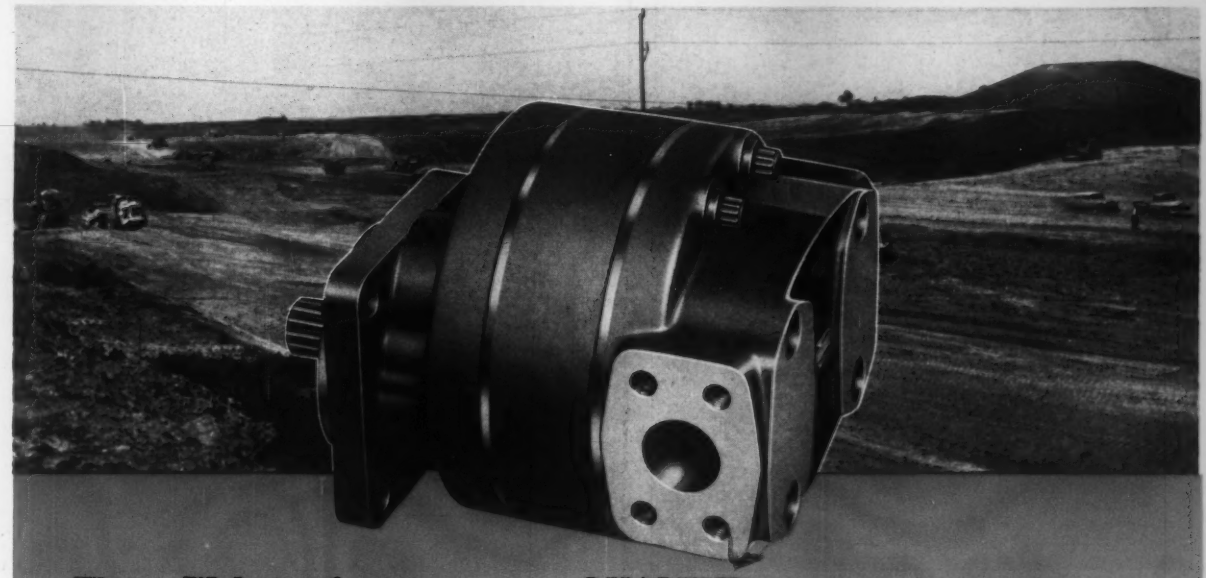
Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

Circle 482 on Page 19

capacity for Big payloads

Now you can have all the advantages of Webster pumps in capacities up to 124 gpm. New "HF" series are high capacity, gear-type pumps especially designed for heavy earth moving and construction equipment. Built to perform under heavy shock loads, long continuous operation. The "HF" series is available in 5 sizes, with capacities from 18 to 124 gpm, operating pressures up to 1500 psi and operating speeds to 2400 rpm. Like all Webster hydraulic pumps, the new big capacity series is compact for easy adaptation to your product . . . operate at maximum efficiency on low power requirements.

NEW Webster "HF" SERIES HYDRAULIC PUMPS



These Webster features mean QUALITY!

1. Integral drive, idler shaft and gear assembly.
2. High capacity roller bearings at all four bearing points.
3. Ball bearing to absorb end thrust.
4. Internal splined shaft (no keying problems).

WRITE for facts, figures and data on the new Webster "HF" series pumps.

Call the man from Webster

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

CAPACITY RANGE OF "HF" SERIES PUMPS

Ratings shown are tentative standards which may be changed to meet your own requirements.

MODEL	GEAR WIDTH, INCHES	DISPLACE. CU. IN. PER REVOLUTION	GPM @ 1200 RPM & 1000 PSI	GPM @ 1800 RPM & 1000 PSI	GPM @ 2400 RPM & 1000 PSI
10 HFS	1	4.3	18	30	41
15 HFS	1½	6.5	28	45	61
20 HFS	2	8.6	38	60	83
25 HFS	2½	10.8	52	76	112
30 HFS	3	13.0	59	92	124

Circle 483 on Page 19

Republic Steel Announces Result of Project 501...

A NEW HIGH STRENGTH POWDER

Type 6460 Developed for Use in Higher Stressed Applications! Suited to Existing Operating Equipment! Provides High Strength With Lower Cost!

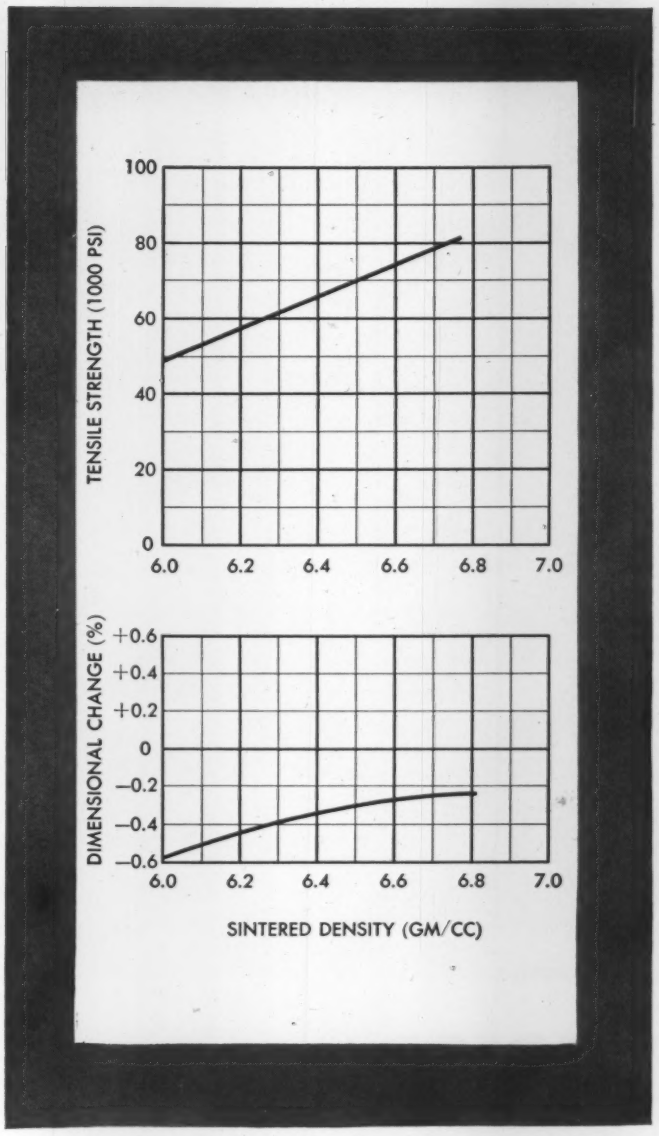
Again, the big news in the powder metallurgy industry comes from Republic Steel. First, Republic gave the industry powders with controlled dimensions. Now, at its Toledo, Ohio plant, Republic has developed, tested, and is *producing* a new **H**igh **S**trength Powder which permits the use of sinterings for highly stressed parts.

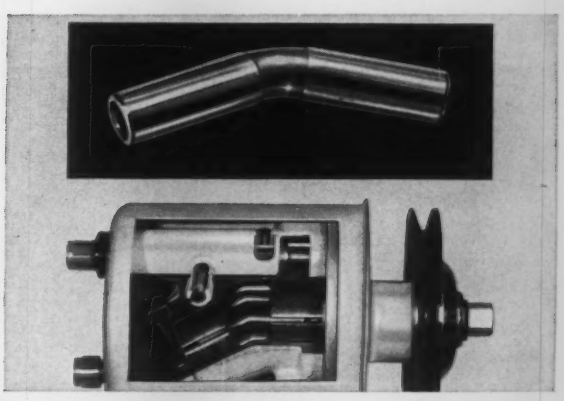
This new powder, designated Republic Type 6460, provides these advantages and features:

- Minimum tensile strengths at 6.4 density of 60,000 p.s.i. as sintered, and 100,000 p.s.i. heat treated, as determined on standard MPA Test Bar.
- *Can be used with existing operating equipment.*
- Normal briquetting pressures—30 to 35 tons to obtain a density of 6.4 grams/cc.
- Normal sintering cycles—2030°F. to 2050°F.—45 minutes—Endo Atmosphere.
- Normal heat treat procedures—additional information to obtain higher physical properties available upon request.
- Dimensional characteristics after sintering acceptable by commercial practices indicated by the industry—less than .004 inches per inch shrinkage from die size at 6.4 density.
- Available in *production quantities* up to and including 12 tons, or in multiples thereof.

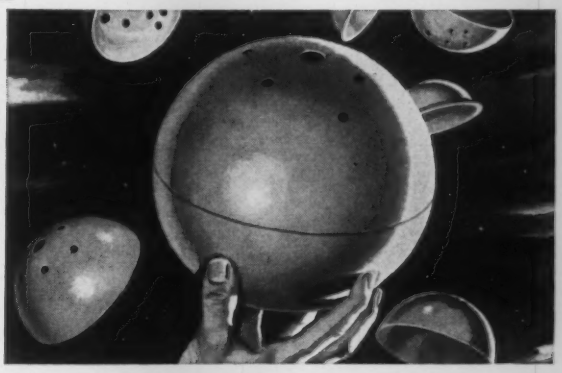
Republic Type 6460 Powder represents an entirely new, but thoroughly practical material for the powder metallurgy industry. It opens the way to new markets for new applications of **H**igher **S**tressed parts at lower costs.

Our metallurgists and engineers are ready to help you utilize all the advantages of Republic Type 6460 Powder. Just mail the coupon to obtain their services, or for technical data sheet on Type 6460 Powder.





WHEN IT'S MOVING... MAKE IT TUBING. Republic ELECTRUNITE Mechanical Tubing meets all close tolerance requirements for new Thompson Products automotive hydraulic pump assembly. Close tolerance, uniformity, ductility, workability—four important performance requirements, all important reasons why ELECTRUNITE is used. Will-O-Hill Industries, Inc. Willoughby, Ohio, sub-contractor, cut 7/16-inch diameter ELECTRUNITE into units 2 3/16 inches long. Each unit is rolled to form a slight groove in the center and bent to an angle of exactly 150°. Nine such pieces are used in each pump assembly. Send coupon for more information.



STRENGTH, LIGHTWEIGHT, CORROSION-RESISTANCE are advantages of Republic Titanium used in the manufacture of these hemispheres by Alloy Products Corporation, Waukesha, Wisconsin. Used for special aeronautical applications, completed spheres provide light weight without impairing safety; strength to contain 2,000 psi.; extremely high corrosion-resistance to chemically active contents. Beyond providing product advantages, Republic Titanium is easy to draw, pierce, and weld. Little change in fabricating procedure is required as compared with other construction materials. Send coupon for data.

REPUBLIC STEEL

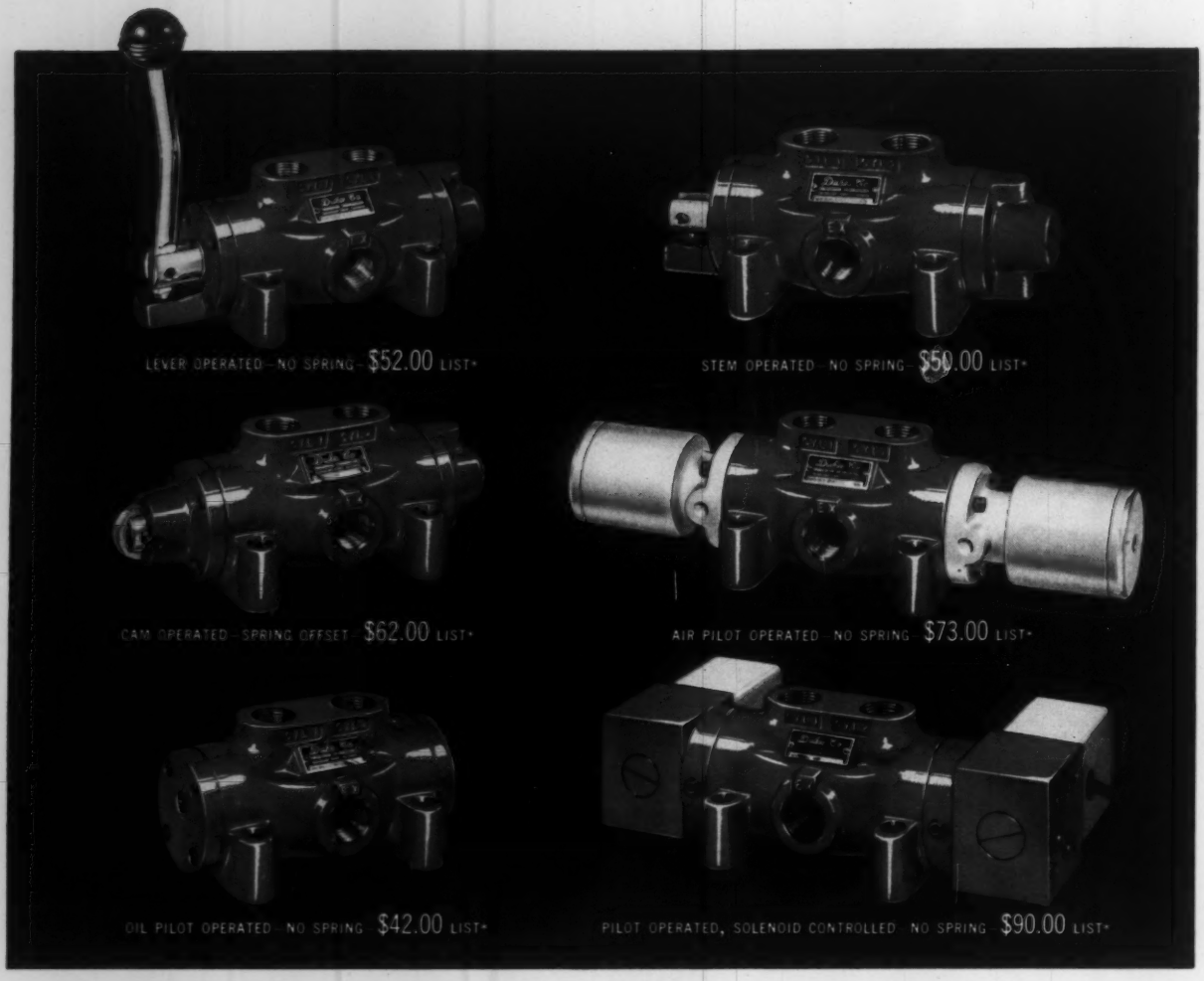
World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-5430-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

☐ Have a powder metallurgist call.
Send more information on: ☐ Type 6460 Powder
☐ ELECTRUNITE® Tubing ☐ Titanium

Name_____ Title_____
Company_____
Address_____
City_____ Zone____ State_____

Circle 484 on Page 19

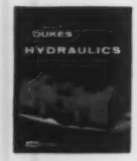

LEVER OPERATED—NO SPRING—$52.00 LIST*
STEM OPERATED—NO SPRING—$50.00 LIST*
CAM OPERATED—SPRING OFFSET—$62.00 LIST*
AIR PILOT OPERATED—NO SPRING—$73.00 LIST*
OIL PILOT OPERATED—NO SPRING—$42.00 LIST*
PILOT OPERATED, SOLENOID CONTROLLED—NO SPRING—$90.00 LIST*

CHECK the prices! COMPARE the specs!

You'll find this NEW line of valves costs less and operates to higher requirements

. . . and TANDEM SPOOLS are available at no extra cost

Send for complete new Dukes Catalog



- Available for pressures up to 3000 PSI
- Choice of 4 spool actions: spring centering, spring offset, no spring in detent or friction pad type
- Choice of 3 standard spools and 5 alternates
- National Acme solenoids
- Full area internal porting
- ½" and ¾" pipe sizes

**prices applicable in the U.S.*

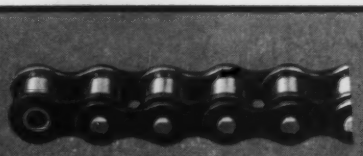
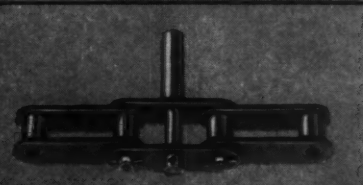
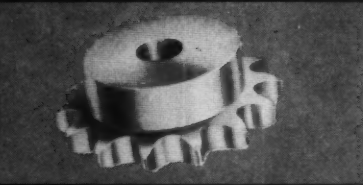
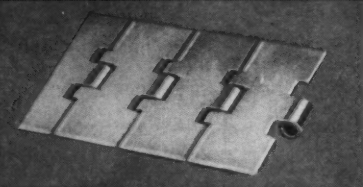
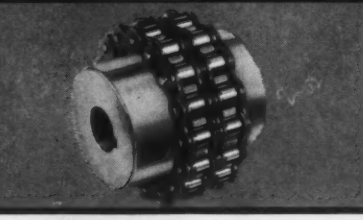
DUKES

HYDRAULIC OIL VALVES

Dukes Company Inc. • 3999 North 25th Avenue • Schiller Park, Ill. • A Chicago Suburb

Circle 485 on Page 19

PUT MORE GO IN EVERY DRIVE WITH THIS ATLAS TRANSMISSION TEAM!

STANDARD ROLLER CHAIN		Complete line of Roller Chain ⅜" pitch through 2½" pitch—A.S.A. regular, heavy, single and multiple strand chain carried in stock. Alloy, Electrolized, bronze or stainless steel.
SPECIAL ROLLER CHAIN		Extended pitch, cable or sling chains, attachment chain or special chains to specifications. Atlas makes them all and stocks many sizes for quick deliveries.
PRECISION FITTED SPROCKETS		Complete line of precision made roller chain sprockets to A.S.A. specifications ⅜" pitch through 2" pitch carried in stock. Available in heat treatable steel, bronze, Electrolized and stainless steel.
CONVEYOR CHAIN		Atlas FLAT-VEYOR Chain and sprockets. Complete line of both Electrolized and carbon steel carried in stock. Also available in stainless steel upon order.
FLEXIBLE COUPLINGS		Complete line of steel chain couplings, carried in stock. Stainless steel, bronze and Electrolized are available made to order.

Atlas Roller Chain, Sprockets and Flexible Couplings are precision matched to operate as a power team for peak efficiency. They are made to run quieter, last longer and require less maintenance. They are a *power team* to provide higher efficiency and longer life on every type of installation.

ATLAS CHAIN & MANUFACTURING CO.
West Pittston, Pa.

Please send me data for designing more efficient power drives.

Name _____ Title _____

Company _____

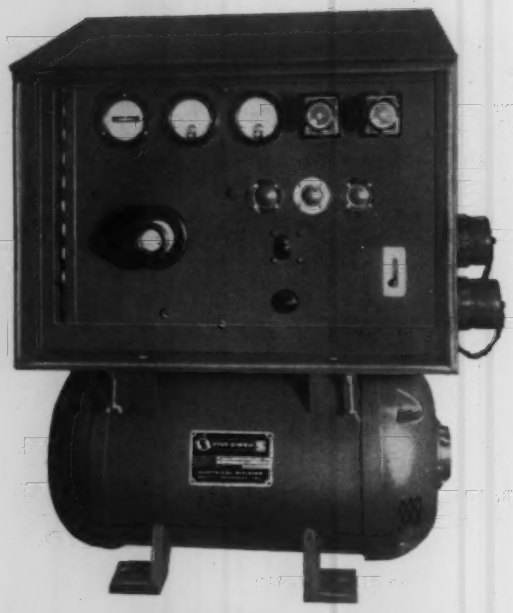
Address _____ State _____

City _____

ATLAS

POWER TRANSMISSION PRODUCTS

Circle 486 on Page 19



New "400"-Cycle POWER PACKAGE!

UNIT-MOUNTED

- **Motor**
- **Inductor-Alternator**
- **Regulation**

Motor-Generator Sets by

STAR-KIMBLE

Circle 487 on Page 19

THE PACKAGE:

- *A single compact unit.* Motor, alternator and controls built in one easily installed, space-saving construction.

THE MOTOR:

- 220/440 volts, 60 cps, 3 phase.

THE INDUCTOR-ALTERNATOR:

- *Wide choice of outputs.* Power range: Made in 1.5, 3, 5, 7.5 and 10 kw ratings at .8 power factor and with voltages of 120/208, 3 phase; 220/440 volt, 3 phase; 115/230 volt, single phase. Standard frequency 400 cps; other frequencies can be supplied.
- *Close voltage regulation.* Plus or minus 2%. (Plus or minus ½% can be furnished with special magnetic amplifier control).
- *Low maintenance.* No commutators, slip rings or rotor windings.
- *Low radio noise and harmonic content.*

THE CONTROLS:

- *Voltage regulator*—fast-acting automatic. Provision is made for adjusting voltage above and below normal values.

TYPICAL APPLICATIONS:

- Flight Simulators.
- Computers
- Aircraft Ground Support Equipment
- High-Frequency Machine Tools

The machine illustrated above is a 3 kw unit with many special design features not normally needed but indicative of variations available in this series of machines.

Write for complete information on standard designs—or outline your specific requirements for prompt attention by our Engineering Department.

ELECTRICAL DIVISION

including the STAR-KIMBLE product line

SAFETY INDUSTRIES, INC.

P. O. BOX 904 • TEL. UNiversity 5-3171 • NEW HAVEN 4, CONN.

ENTOLETER DIVISION
ELECTRICAL DIVISION

AUTOMATIC TIMING & CONTROLS, INC.
SAFETY RAILWAY SERVICE CORPORATION
INTERPROVINCIAL SAFETY INDUSTRIES LTD.

LIGHTING DIVISION
THE HOWE SCALE COMPANY

Motors • Generators • Disk Brakes • Special Motor-Generator Sets and Control Packages

meets our requirements"

Tough specifications? You bet.

That's why Maginniss Power Tool Company, leading producer of concrete vibrators, brought its tubing problems to Ohio Seamless. Our engineers recommended Ostuco NP-3 C1040 tubing for Hi-lectric Concrete Vibrator housings.

Here's what Maginniss says after using Ostuco NP-3 Tubing exclusively for 11 years, *". . . only Ostuco NP-3 Tubing meets our requirements for abrasion resistance and easy machinability. Its fine grain structure cuts clean every time. Furthermore, we have never had a thread failure in the field traceable to tubing quality."*

Every product, including yours, has materials or production process problems that are uniquely its own. If they involve tubing, Ohio Seamless has the answer. Just contact our nearest sales office, or the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

AA-7477

SALES OFFICES: Birmingham • Charlotte • Chicago (Oak Park) • Cleveland Dayton • Denver • Detroit (Ferndale) • Houston • Los Angeles (Lynwood) Moline • New York • North Kansas City • Philadelphia (Wynnewood) • Pittsburgh Richmond • Rochester • St. Louis • St. Paul • St. Petersburg • Salt Lake City Seattle • Tulsa • Wichita

CANADA: Railway & Power Engr. Corp., Ltd.

EXPORT: Copperweld Steel International Company
225 Broadway
New York 7, New York

FIFTY YEARS
OSTUCO SHELBY, OHIO
OSTUCO TUBING
1908 1958

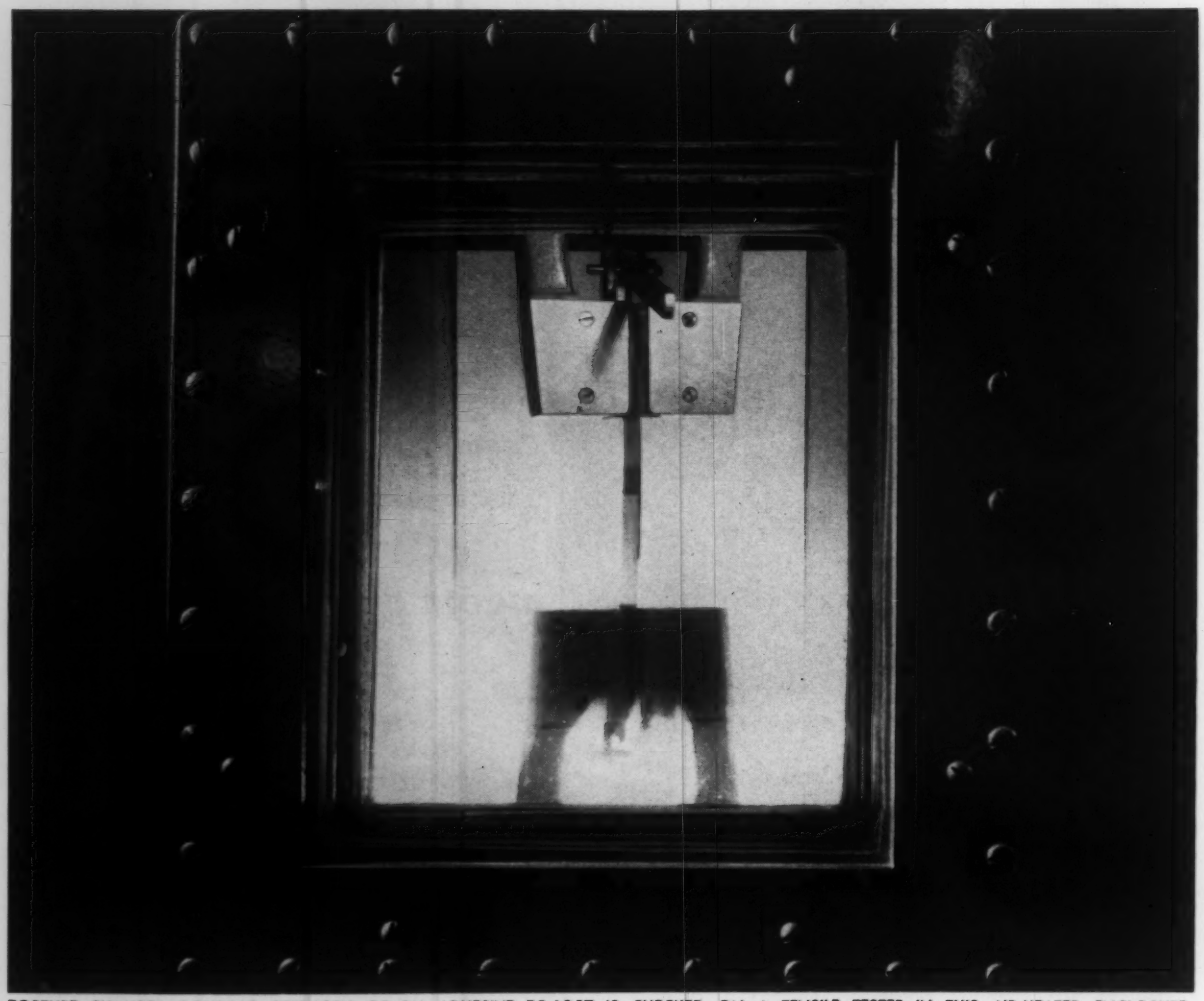
OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

Circle 488 on Page 19

Rugged 3M sandwich adhesive EC-1357 holds 315 psi at 200° F.



TORTURE CHAMBER. BONDING STRENGTH OF 3M ADHESIVE EC-1357 IS CHECKED ON A TENSILE TESTER IN THIS AIR-HEATED ENCLOSURE.

The two metal strips in this tug-of-war are bonded by a tough, heat-resistant 3M sandwich adhesive—EC-1357. On the tensile tester, under a dynamic loading of ½ inch per minute . . . and at searing temperatures as high as 200° F. . . . EC-1357 withstands a stress of over 300 psi.

Rugged grip . . . you bet! But more than that, because it is dark colored, EC-1357 dries faster under infrared heat, and you cut production costs by pre-drying for maximum immediate strength—or cold-bonding on a cold press or nip roller for fabricating at room temperature.

Its remarkably high resistance to moisture, high and low temperatures, and weathering make EC-1357 ideal for installations where climatic changes are sudden and severe. And EC-1357 is easy to spray-apply. Greatly reduced cobwebbing insures better surface-wetting for far better adhesion. And you save materials!

3M also offers EC-1368, a light colored version of EC-1357 which provides the same cold-setting, high strength bond.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

For full details contact our branch sales office near you. There are 19 located in principal cities throughout the United States ready to assist you in technical problems. Six plants provide local service for faster delivery. For free illustrated literature, write: 3M Company, Dept. C-9, 417 Piquette Ave., Detroit 2, Michigan.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Eastman

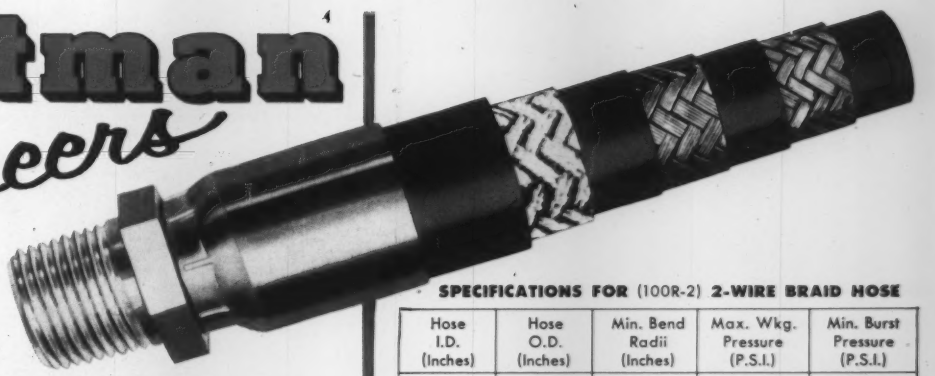
engineers the way

TO HIGHER PRESSURES

Eastman engineering is making possible ever-increasing advances in hydraulic pressures through:

- Couplings designed to exceed minimum *burst* pressure —four times actual working pressure.
- Hydraulic application of couplings to hose, assuring maximum grip—within specified hose tolerance.
- Maximum orifice—designed to improve fluid flow, reduce friction and increase power delivery.
- More rigid testing of completed assemblies to reveal additional opportunities for improvement.

Let Eastman engineers help you increase the "power-performance ratio" of your product to improve *your* competitive position in *your* field.

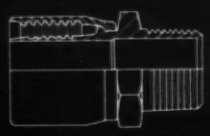


SPECIFICATIONS FOR (100R-2) 2-WIRE BRAID HOSE

Hose I.D. (Inches)	Hose O.D. (Inches)	Min. Bend Radii (Inches)	Max. Wkg. Pressure (P.S.I.)	Min. Burst Pressure (P.S.I.)
¼	11/16	4	5000	20000
⅜	27/32	5	4000	16000
½	31/32	7	3500	14000
¾	1 ¼	9½	2250	9000
1	1 5/16	9½	1875	7500
1 ¼	2	16	1625	6500
1 ½	2 ¼	20	1250	5000
2	2 ¾	22	1125	4500

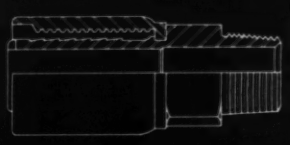
PERMANENTLY ATTACHED COUPLINGS

For 2-wire braid hose. Offers maximum coupling strength, strong hose attachment and improved orifice for rapid, friction-free fluid flow. For working pressures up to 5000 psi. See Pages 10 and 11.



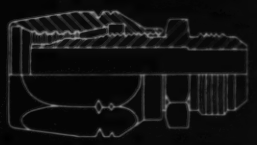
HIGH PRESSURE COUPLINGS

For EXTREME high pressures up to 7000 psi working pressure. Eastman engineered for greater power delivery and performance. For specifications and sizes, send for New Eastman Bulletin 200, below.



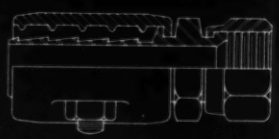
2-PIECE REUSABLE COUPLINGS

For 2-wire high pressure hose up to 5000 psi working pressure. Increases serviceability of your equipment through easy replacement in the field. See new Bulletin for complete details.



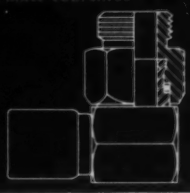
CLAMP TYPE COUPLINGS

Accurate machining assures alternate positioning of clamp ribs between each barb of insert—creating exclusive Inter-Lock grip—available to you only through Eastman. Pages 14 and 15.



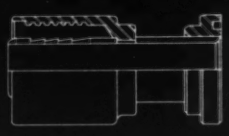
SWIVEL "O" RING MALE COUPLINGS

Permits easy assembly in close quarters, easy positioning of hose in 45° and 90° angles. Economical, reduces number of threaded connections. Dimensional drawings, sizes, and specifications in new Bulletin.



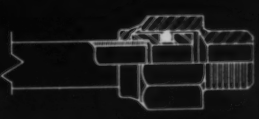
FLANGE HEAD COUPLINGS

Offer advantages of permanent hose attachment plus Split Flange Head Couplings with 0° to 90° stems. Economy plus user convenience. Specifications and sizes listed in new Bulletin.



TUBING ASSEMBLIES

Swivel Male "O" Ring Tube Nut used on tubing assemblies. Eastman offers formed tubing with beaded or flared ends—to your requirements. Specifications and sizes on Page 30.



Eastman

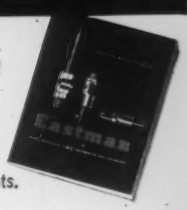
first in the field

MANUFACTURING COMPANY

Dept. MD-9, MANITOWOC, WISCONSIN

Write FOR YOUR NEW BOOK— WITH THAT NEW LOOK!

- A NEW Service Concept.
- A NEW High in Convenience.
- A NEW Ease in Specifying— according to your pressure requirements.



SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

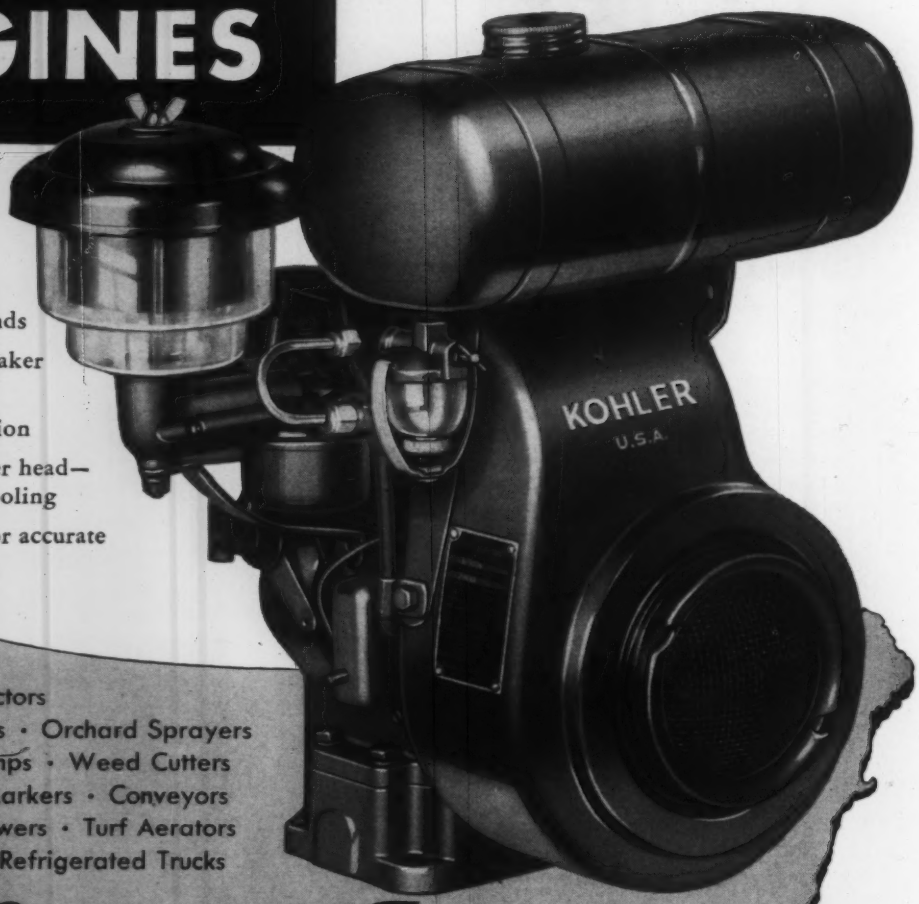
KOHLER ENGINES

4-CYCLE SHORT-STROKE AIR-COOLED

MODEL

K90

- Balanced crankshaft—ball bearings at both ends
- Externally mounted breaker points
- Positive splash lubrication
- Aluminum alloy cylinder head—deep fins for efficient cooling
- Mechanical governor for accurate RPM control



Riding Tractors
Rotary Tillers • Orchard Sprayers
Centrifugal Pumps • Weed Cutters
Highway Line Markers • Conveyors
Riding Lawn Mowers • Turf Aerators
Snow Blowers • Refrigerated Trucks

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Lawn Rollers • Cultivators • Grain Blowers • Milkers • Grain Elevators
Disc Grinders • Pump Jacks • Portable Saws • Sprayers • Motor Bikes
Hoists • Floor Sweepers • Augers • Air Compressors
Concrete Mixers • Vibrators • Scooters • Rail Drills
Sand Spreaders • Spike Pullers • Tie Tampers
Kohler Electric Plants

FROM 3 TO 24 H.P.

Send for 28-page illustrated booklet

KOHLER CO. Established 1873 KOHLER, WIS.

KOHLER OF KOHLER

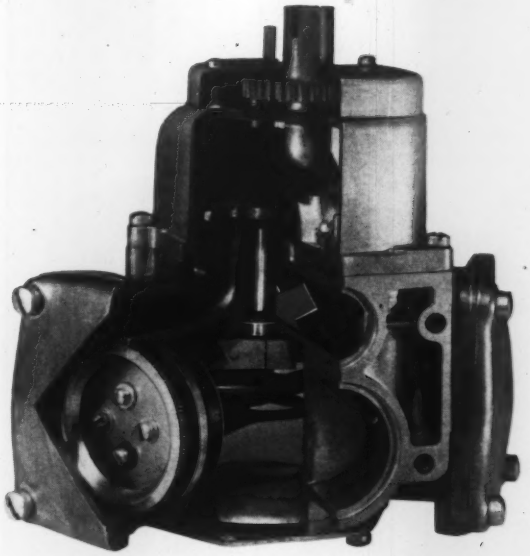
Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings • Electric Plants • Air-cooled Engines • Precision Controls

Circle 491 on Page 19

VITON

TRADEMARK

A New Synthetic Rubber from Du Pont Serves Where Other Elastomers Fail



In this meter for gasoline pumps, the O-ring seal on the output shaft is exposed to aromatic components in high octane gasolines. A noted oil-resistant synthetic rubber was first used for the O-ring. It became swollen, however, and caused metering difficulties. When an O-ring of VITON was substituted, the trouble was eliminated.

Gives unequalled service in oils, fuels, solvents and chemicals at temperatures over 400° F.

VITON synthetic rubber combines high resistance to most fluids and corrosive chemicals with outstanding resistance to high temperatures—up to 450° F. in continuous service, up to 600° F. in intermittent service.

VITON offers excellent mechanical properties for a fluid and heat-resistant elastomer. Specimens return to within 90 to 97% of their original dimension after being compressed 25% for 70 hours at 250° F. At room temperature, tensile strength tests out from 2000 to 3000 psi, and ultimate elongation from 100 to 400%, depending upon hardness.

VITON is easy to process; components can therefore be made to close tolerances. This new synthetic rubber has already proved successful in precision seals (such as the one shown here), diaphragms, coated fabric and linings. To learn more about VITON, see your rubber supplier or send for our new booklet. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-9, Wilmington 98, Del.

RESISTANCE TO FLUIDS AND CHEMICALS

VITON vulcanizates were immersed for 7 days in a wide variety of corrosive fluids. These data show the effect of representative fluids upon the properties shown.	Tensile Strength Retained %	Hardness Change Points	Volume Increase %
Carbon tetrachloride, 75° F.	85	+ 2	1.3
Aniline, 75° F.	100	— 1	3
Tricresyl phosphate, 300° F.	93	—11	24
JP-5 petroleum aircraft fuel, 75° F.	100	+ 1	0.4
Turbo oil No. 15 diester lubricant (Mil-L-7808), 400° F.	60	— 6	19.6
Transmission fluid, Type A, 212° F.	77	— 1	1.5
OS-45 silicate ester, 400° F.	62	— 3	11.1
Sodium hydroxide, 46.5%, 75° F.	75	+ 1	2.1
Hydrofluoric acid, 48%, 75° F.	98	+ 2	4.8
Sulfuric acid, fuming, 75° F.	58	— 4	4.8

VITON

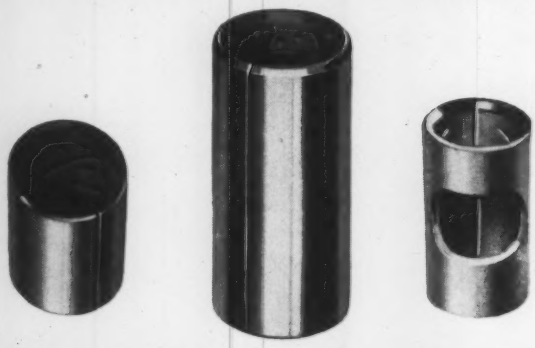
DU PONT

REG. U.S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

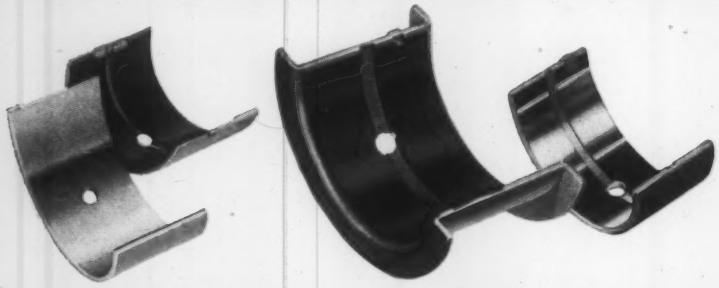
Bimetal and Plain Bushings offer substantial economies

Rolled split plain bronze, steel or aluminum; or steel lined with bronze, babbitt, medium or heavy-duty copper-alloy, or extra heavy-duty aluminum alloy. Many design variations possible, plus volume production economies.



These alloy linings meet 95% of engine bearing needs

Experience shows a steel back, lined with tin- or lead-base babbitt, medium- or heavy-duty copper-alloy or extra heavy-duty aluminum alloy, meets most performance requirements.

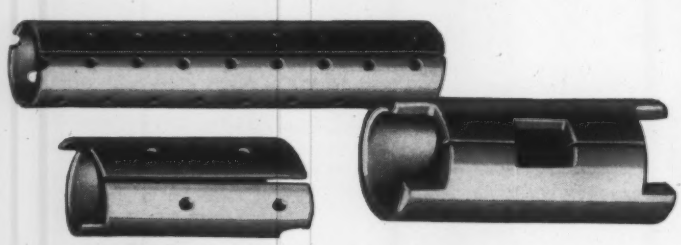


Precision Thrust Washers in Bronze or Bronze on Steel

Cold rolled for heavy duty. Steel faced with copper-alloy on one or both faces. Nibs, lugs, coined oil grooves. Flat, spherical or special shapes. From 1″ to 6″ O.D.

Economical Spacer Tubes for Hundreds of Applications

Money-saving substitute for iron pipe, tubing or machined parts. Delivered ready for assembly, to exact dimensions —or can be brazed to other components.



FEDERAL Mogul SINCE 1899

FEDERAL-MOGUL DIVISION

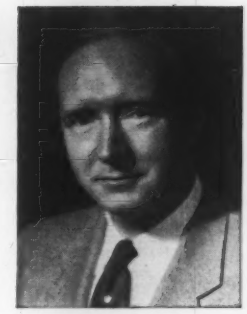
FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Circle 493 on Page 19

MACHINE DESIGN

September 18, 1958



Needed—Breakthrough on Costs

BLAME for the recent recession cannot be pinpointed. Effects of numerous factors seem to have piled up on each other to produce a setback that was as disastrous—to those affected—as it was unexpected.

Prevention of a recurrence is more important than attempting to assign blame. But the intelligent approach is to study all possible contributors to the business slowdown, then start to correct the faults.

A frequently heard complaint has been, "We've priced ourselves out of the market." It has been applied to domestic and foreign, as well as to capital and consumer goods markets.

Effect on prices of the rising cost of labor is self-evident. But no one in his right mind expects organized labor to go back to lower wage scales or even to quit demanding higher scales. That is one of the facts of life.

Another fact of life: The buying public is still highly price conscious and will continue to resist efforts to be sold the same, or lower, quality products at higher prices.

These two facts add up to a deadlock. In the absence of some sort of major breakthrough we can expect to continue merely in a state of uneasy equilibrium between inflation and recession. We need breakthroughs of the sort that Henry Ford accomplished with the Model T, whereby customers and employees both benefited.

Here is a real challenge to creative-minded design engineers. D. W. Karger has put the problem in a nutshell. In his penetrating article beginning overleaf he makes the point that "a product is worthless if it cannot be produced at a cost below its market value." Can you, despite rising labor costs, design to maintain total costs below what the customer is willing to pay? If you can do that without sacrificing product quality and appeal—brother, you've got it made.

Colin Carmichael

EDITOR

How to determine

NEW-PRODUCT COSTS

By DELMAR W. KARGER
Manager
New Product Development
Magnavox Co.
Fort Wayne, Ind.

One of the most crucial steps in development of a new product is determining its cost. Since the estimated cost may spell yes or no to the project, the engineer should know how this is determined—whether he is responsible for, or subject to, the outcome. This article provides an insight into the process, and offers suggestions for those responsible for estimating product-development costs.

PROBLEMS associated with costing a prospective new product are among the most important encountered during its development. A product is worthless if it cannot be produced at a cost below its market value. Determining this cost will almost invariably require many estimates—not just one or two tries.

Market value is determined by the selling price of competitive products or by the worth to a customer if no competitive product exists. A price goal established by an existing competitive product makes designing and manufacturing a sufficiently profitable product much more difficult. The established manufacturer has already absorbed all or much of his starting cost. After a price goal is established, the real work begins of establishing how and/or whether the product can be made and sold with an adequate profit margin.

The Cost Elements

Numerous specific cost elements must be considered both separately and in combination with each other. A suggested check list of these elements is given in the head of this article. Development of costs for many of the elements requires separate cost analyses, but total costs must be summarized to see if the desired goal has been reached. A typical cost-summary form is shown in Fig. 1. Although this form is described as used for pricing new products, it can be used to analyze cost of existing products.

Preproduction Engineering

It is not necessary to segregate development engineering and product-design engineering. If both are involved, they can be handled as a part of preproduction engineering. Preproduction-engineering cost is that which will be necessary prior to start of production. A preproduction engineering estimate is shown in Fig. 2 on a typical estimating form.

Involved in preproduction engineering are such items as:

1. Engineering time to investigate the problem.
2. Junior engineer and/or technician time to support the investigation.
3. Drafting time for preliminary and final drawings.
4. Packaging-engineering costs to design the package and shipping carton.
5. Specification-engineering costs for integrating new-product specifications into established company standards.
6. Labor costs for working models.
7. Consulting groups within the company that need to be contacted on a given product.
8. Technical-publication costs where literature is needed for marketing the product.
9. Engineering contracted outside.
10. Material needed by the preceding classifications. Be sure to check each classification for related material costs.
11. Engineering overhead.
12. Procurement and transportattion costs for material purchased.
13. Travel caused directly by the project.
14. Equipment costs associated with preproduction engineering, such as special machines and test equipment.
15. Miscellaneous expenses, such as outside laboratory service, consulting expense, patent-license fees, and associated legal expense.

. . . *a look at the cost factors that tell if a new product will make money* . . .

Preproduction engineering
Support engineering
Facilities
Equipment
Tooling and material handling
Purchased material
Direct labor
Shrinkage
Scrap
Transportation
Overhead
Selling expense
General and administrative
Patent costs
Taxes

This check list covers the usual items, but it is impossible to predict every cost that may be encountered. The check list does provide for most items that are frequently forgotten, such as making test pieces to submit to the government or to prospective customers for evaluation. This type of item is often overlooked and is noticed only when the estimate is overrun. Multiple rechecks of any cost estimate are absolutely necessary if all costs are to be correctly delineated.

While preproduction engineering is a legitimate charge to a new product's over-all cost, usually this cost cannot be recovered during the first year of production. To avoid forcing the selling price up to a noncompetitive level, the cost is amortized over a period of several years (usually 2 to 5).

A portion of the profit from sale of existing products must be used to provide for the future of the company. Some of this money can be used for new-product preproduction-engineering costs. Several of the other cost elements may also have to come from profits on existing products.

Preproduction engineering in the example in Fig. 1 has not been amortized over any total expected output since the company felt this was a legitimate charge against existing products. The cost is shown for information purposes but not as a charge against the prospective new product.

Production-Support Engineering

Costs incurred by engineering during actual production of the product fall in this category. Even though the engineering department has developed the product, produced drawings, and tested working models, its help will be required after the product is in production. Amount of cost incurred will be much less than the preproduction cost. It is, however, a tangible element of cost that cannot be overlooked and it may be quite large during the first 6 months of production. The items of cost involved are essentially the same as those for preproduction engineering and the same check list should be used. Production-support engineering was considered a legitimate charge against the prospective new product in the cost analysis shown in Fig. 1 and was amortized against the expected first year's production of 150,000 units.

Facilities

Items included in facilities will vary from company to company. Definition of the included items will generally be established by the comptroller's department in industry and its counterpart in government. The guide or actual delineation ordinarily will be found in an accounting procedure or policy statement.

Facility costs are usually those associated with establishment of any new buildings, storage equipment, factory furniture, pallets, and other general items that could have a future use on other products, as opposed to special-purpose items which can be utilized only on the new product. Normally, most of these items are already available and there are few miscellaneous costs. As such, this cost element serves as a "catch-all" division. The items can be subdivided into capital and expense charges—a division that accounting will probably require.

The new-product manager may make this latter subdivision if management insists on charging part or all of the facility costs to the new product. Capital items are normally depreciated over a substantial period (10 to 30 years) and the depreciation is charged into overhead to become an assessment against direct labor. This procedure is advantageous to product development.

Expense items may also be amortized, for product-costing purposes, over a short time period, such as 2 to 3 years. Charging the product upon payment

of the expense-item invoice is the standard accounting-department method for handling expense items. While the expense items may be charged off the company's books when the invoices are paid, the delayed procedure is of value in costing the new product. In effect, the new product is granted a no-interest loan and allowed to repay it over an extended period. The effect is the same as that experienced with capital expenditures.

Facility costs will normally be provided by the industrial or plant-engineering functions. They can do this only after they are provided with run rates, first-year production quantities, future production forecasts, product drawings, specifications, etc. In the initial efforts to cost the new product, it may be possible to simply "guesstimate" the probable facility cost, if any, rather than make a detailed estimate.

THE NEW PRODUCT COMPANY
New York, New York

BR. or Est. No. 2536
Date January 5, 1958
Page 1 of 1

Cost Estimate
Bid Estimate
Engineering
C.P.F.F.
Fixed Price
Cost Indication
Make-Buy

Customer No.:

Distribution	Customer: Manufacturers of Military Electronic Equi	Item #	Qty.	At (unit cost)	Amount
H. B. Allen	Article: Special high-temperature elec-				
G. M. Clark	trolytic capacitor having extremely low				
J. E. West	electrical leakage				
I. Newman		1	150M	$6.70	$405,000.00
	Representative unit				

		%	1
1	Material		2.78
2	Shrinkage	2	.06
3	Procurement	5	.14
4	Transportation	1	.03
5	Total Material		3.01
6			.34
7	Labor		.03
8	Efficiency	90	.37
9	Total Labor		
10			.67
11	Overhead	181	not charged
12	Pre-Prod. Engr.		.19
13	Tools Etc.		.13
14	Prod. Support Engr		4.37
15	Engineering Labor		
16	Engineering O/H		
17	Total Mfg. Cost		
18	Interest		.22
19	Gen. & Admin.	5	.04
20	Institutional Adv.	1	
21	Royalties		
22			
23			4.63
24	Total Cost		2.07
25	Desired Profit		6.70
26	Des. Selling Price		2.07
27	Actual Profit		6.70
28	Act. Selling Price		

Delivery and F.O.B. Point: New York, N. Y.

J. Blow, Product Manager
J. E. West, Engineer
E. M. Clark, Cost Estimating
J. Adams, Estimator

Fig. 1—Cost-summary form for a capacitor with a selling price of $6.70. Preproduction engineering is charged against the company's R and D budget, but is amortized over estimated first-year production for costing purposes. Tools and facilities are grouped in one charge and amortized over three-year period; therefore, only one-third is charged to first-year production.

Few facilities will normally be required to start production of the ordinary new product—assuming that a well-established company is introducing it. This is especially true if the new product is similar to those being produced since there is usually some surplus of facility items. The surplus, coupled with the minimum requirements usually associated with initial production, can usually satisfy facility needs for starting up.

Often, when these needs are initially discussed, estimating groups will say that no surplus facilities exist. Since no operating group wants to give up its safety margins on facilities, tools, and equipment, persuasion of a high degree is needed. Ultimately, if the overall good of the company is sufficiently emphasized, reluctance can be overcome. A good place to look for facility items is in special storage areas such as warehouses. The more remote the location of such storage, the less likely that anyone actually knows what is there.

While it may be necessary to purchase a few facilities, some sacrifice of ideal layout and production-process concepts will help the problem. For example, it may be found necessary to accomplish the work in several departments, rather than in one integrated production activity.

Facility, equipment, and tooling costs are all handled as shown in the example cost analysis. They are usually amortized over the expected production for the first 3 years.

Equipment

Manufacturing-equipment cost is generally a variable function related principally to the design, maximum anticipated run rate, and minimum expected years of production of the new product. Other factors affect the equipment cost, but these are the major ones. These same factors apply to tool cost and to jig, fixture, and material-handling equipment costs.

The industrial-engineering department plays a prime role in projecting, and reducing, equipment costs. Its first task is to tentatively decide which items to make and which to purchase. The second, and concurrent job, involves engineering the manufacturing process. This may involve automation to the ultimate, or it may mean an essentially unmechanized process. Cost of equipment for each operation in the production process must be balanced against estimated labor savings. The choice between mechanization or hand operation will affect the cost of purchased materials and may require a slight material-specification change. Design engineering must aid in any design revisions required to keep cost at a minimum. Purchasing, directly and through vendors, can also make valuable contributions. All too often, engineering is reluctant to make necessary concessions on tolerance, material, and mechanical shapes. Co-operation and common sense are the keynotes during the gestation period of a new product.

This complicated trial-and-error process can often extend over a lengthy period before final decisions are reached. Rarely is the possible profit margin on a new product adequate as it is predicted on the first, or even the second or third, cost estimate.

The new-product manager must not leave this work to the functions actually doing the work. It is usually piled on top of an already loaded schedule, is the last thing done, and then given only cursory attention. The project must be nursed along and all possible different combinations must be tried.

It is of material help if the new-product manager himself is able to contribute directly to the effort. The product must be continually rescued from the scrap heap—not only in the estimating phase, but in the others involved in creating the product. However, estimating will take up a major portion of his time.

High labor rates plus high overhead rates often make considerable use of mechanization economical. Automation equipment is usually classified by the accountant as capital equipment but it should be entered in the cost analysis as an accelerated-write-off item (2 to 3 years maximum if it is specialized equipment not readily usable for other products).

Sometimes management can be convinced to use all or part of the first year's potential profits to pay for equipment, tooling, etc. This arrangement will assist in attaining a required selling price.

Tool and Material-Handling Equipment

This cost element, especially tool cost, consists of both vendor and internal cost. The general parameters are similar to those of equipment cost. Also, the remarks concerning existing facilities apply to this item. Costs associated with this element should be delineated concurrently with work on other cost elements.

Purchased Material

It is wise to have vendor quotations for purchased parts indicate special-tool cost separately from piece or material selling price. This procedure facilitates:

1. Analysis of the quotation.
2. Obtaining the lowest price on repeat orders.
3. Maintaining control of tooling to prevent vendor from using it for a competitor or to permit securing the tooling in order to make the part or to appoint another vendor.
4. Tool charges can be amortized over the first order, over any arbitrary quantity, or charged against future profits.

Direct Labor

Establishing the direct labor to manufacture a new product is an extremely difficult task, yet a matter of prime importance. It should occur concurrently with establishing equipment, facility, tool, and material costs. Generally, these costs are at

least partially dependent upon each other and usually each of them affects direct labor. If an advanced degree of mechanization is used, labor will be minimum. Expenditure for equipment and tools to reduce manual-labor costs is largely dependent upon anticipated production quantities.

Presence or absence of competitive products has a great influence. If there is no competition, the selling price can often be established high enough to cover heavy initial manufacturing costs. Thus, the capital investment could be kept low and the high accompanying labor cost accepted.

Product design affects each of the cost elements mentioned. Where competition exists, it is normal

ESTIMATE OF ENGINEERING COST — BID REQUEST NO. 2536 — DATE — ☐ CPFF ☐ FIXED ☐ OTHER ☐ R&D ☑ PRODUCTION

PRODUCT Special high-temperature electrolytic capacitors — CUSTOMER Various

QUANTITY 150,000/year — PROPOSED SCHEDULE PERIOD 12 months

		MAN MONTHS	Pre-Prod. Engineering	MAN MONTHS		MAN MONTHS	Support Engineering First Year	MAN MONTHS		MAN MONTHS	
ENGINEERING LABOR	26										
SENIOR ENG.	23	1.7		12410000							
ENGINEER "A" (Mechanical)	21										
ENGINEER "B"	19										
JUNIOR ENG.	22										
SR. LAB. TECH.	20										
LAB. TECHNICIAN "A"	17										
TECHNICIAN "B"											
ENG. AIDS (HOURLY)	21										
SR. DESIGN DRAFTSMAN	21										
CHECKER	19	.8		43200							
DESIGN DRAFTSMAN	18										
JR. DESIGN DRAFTSMAN	15										
DETAIL DRAFTSMAN	20										
PACKAGING ENG. "B"	20										
SPECIFICATION ENG. "B"	18										
JR. SPECIFICATION ENG.	19	4		220000							
MODEL MAKER "A"	17										
MODEL MAKER "B"	17										
MECHANICAL INSPECTOR	15										
MODEL MAKER APPREN.	26	11		858000			12		740000		
SR. CHEMICAL ENG.	23										
CHEMICAL ENG. "A"	21										
CHEMICAL ENG. "B"	19										
JR. CHEMICAL ENG.	17	13		429000			6		240000		
CHEMICAL TECH. "B"	22										
EDITOR &/OR ARTIST	20										
SR. WRITER &/OR SR. TECH. ILLUST'R	17										
JR. WRITER &/OR JR. TECH. ILLUST'R											
ASSEMBLY SHOP (SALARIED)											
ASSEMBLY SHOP (HOURLY)											
FACTORY ASSISTANCE (HOURLY)											
TOTAL ENGINEERING LABOR				1674300					980000		
ENGINEERING OVERHEAD @ 90 %				1506870					882000		
ENGINEERING MATERIAL				536000					800000		
REPRODUCIBLE D'W'GS				15000							
TOTAL MATERIAL				551000					800000		
PROCUREMENT @10 % R & D ONLY				55100					80000		
TRAVEL				100000							
SUB-CONTRACT ENGINEERING											
PURCHASED TEST EQUIPMENT				557500					1950000		
Special Tools				4444700							
TOTALS									.13		
UNIT COST			Not to be unitized								

APPROVED — SECTION CHIEF H. Billings — DATE Jan. 5, 1958 — CHIEF ENGINEER G. E. West — DATE 1/31/58

Fig. 2 — Estimation of pre-production and support engineering for new capacitor.

to frequently modify the design to gradually lower manufacturing costs until competitive requirements are met. The more competition that exists, the more necessary it is to precisely determine each cost element—especially direct labor.

Industrial engineering will usually break down the direct labor to a specified time per operation. This is the time for a fully trained operator to perform the task when working with average skill and effort. To this time is added personal, fatigue, and delay allowances. The sum is the allowed time, to which is added items such as rest periods, material handling, instruction, group leaders, pilot run, initial training, rework, repair, and labor inefficiency. It is important to have industrial engineers break down the direct labor on an important estimate and to make them justify each item.

Starting direct-labor costs are high. Labor performance, when compared to allowed standards, is poor in the beginning months of production due to pilot-run cost (as much as 20 to 30 times standard allowed labor), training the operators, and excessive rework and repair.

Shrinkage

Many cost items can become buried under "shrinkage." It is intended to cover ordinary material losses, overbuys, and accepted overshipments. It is not intended to cover cases where units or sections of a unit must be scrapped, such as during destructive tests, or where the unit cannot be repaired if it fails after assembly and adjustment. These latter instances should be considered scrap.

Material losses will occur because of pilferage, loss or damage from carelessness in handling, and unauthorized usage of parts for various purposes. Vendors are normally permitted to over and undership certain types of parts by a small percentage. This causes an unbalanced inventory and may increase product cost. Some parts are damaged in processing due to errors or accidents. All of these situations cause inventory shrinkage that must be considered in the cost.

Usually the cost estimator adds a percentage of the unit material cost to compensate for shrinkage. During production, the material-control department arrives at percentage factors for shrinkage of various classes of materials used, based upon actual experience. These should be used when applicable.

Total shrinkage varies from a fraction of 1 per cent up to 5 or 10 per cent. Amount depends on the product, classes of parts or materials involved, complexity of the product, degree to which engineering has completed its task, factory experience with similar products, quantity produced, controls used, and run rate. On large-quantity production of almost any kind of product, shrinkage is well under 5 per cent. Material control pays most attention to control of more expensive parts and normally keeps shrinkage under 2 per cent—often down to 1/10 of 1 per cent. Fewer controls are imposed on the low-price parts and shrinkage is often allowed to go over 10 per cent. Therefore, estimating shrinkage by part classification and/or cost is sometimes followed in preparing the cost estimate.

Cost estimating and material control will be doing some guessing on amount of shrinkage, even for a known product. This guessing will be considerably greater on a new product significantly different from the regular line. The applied shrinkage factor should be tested for common-sense reasoning. It could be much too low or much too high.

Scrap

Since scrap affects both material and labor, it is usually handled as a percentage factor in the cost analysis, the same as shrinkage. In the case of material, scrap is usually applied first and then shrinkage is applied to the sum of the base material plus the scrap. This is proper since shrinkage, as defined, would apply to both base material and extra material ordered to cover scrap. In the case of labor, scrap should be applied to total expected labor required to produce the products, not to base or allowed-time labor. Since expected labor for starting the run will be considerably more than the allowed labor, time wasted on production of scrap will also be considerably higher during early production runs.

Shrinkage and scrap are applicable to a degree to estimation of engineering material and labor, although it is unusual to attempt to define shrinkage or scrap for engineering. Occasionally, expensive products manufactured by a competitor are purchased with the intent to dismantle them for analysis. This could be an important cost element and would need to be considered in the engineering estimate, just as shrinkage of production material must be considered.

Transportation

Expense of transportation to the manufacturing plant is primarily concerned with materials used in manufacturing. However, it is also a factor in cost elements such as engineering, equipment, and tools.

Frequently the estimated price secured by purchasing is F.O.B. the vendor's plant and it is necessary to anticipate transportation expense. This can be done by applying a percentage factor against the value, based on past experience. Segregation by class of purchased material may increase accuracy. Actual transportation cost of heavy equipment can be estimated by purchasing or traffic departments.

Overhead

Handled as a percentage application against direct labor, overhead covers indirect manufacturing costs—but not indirect expenses, such as advertising,

general administrative, interest, and selling. Overhead is usually divided into two fundamental divisions, fixed and variable. Fixed-overhead charges are essentially constant as long as the plant or factory continues to operate. Examples are rent, building upkeep, heat, and some salaries, such as those for the factory manager, general foremen, watchmen, and perhaps a portion of the maintenance crew.

Variable-overhead expenses depend directly on the level of manufacturing activity. Examples are supervisor's salaries, cost-accounting salaries, receiving and shipping department operating costs, machine maintenance, material handling, etc. Variable overhead usually is less than 50 per cent of the total plant overhead, and may vary widely among manufacturing departments.

Sometimes, the new-product manager can gain some advantage from this situation. For example, if the prospective new product is a component used in the manufacture of an end product, management may agree to charge only the variable overhead during the initial production. In fact, this is often the basis for handling overhead when arriving at a "make-buy" decision. When the product can be absorbed in the plant, this procedure will assure recovery of all extra real costs. Later, the new product's share of the fixed overhead can be absorbed since starting costs are then eliminated and a greater overhead can be accepted. This is a legitimate way to look at the introduction of new products into the line.

Another approach to overhead charges is to set up a special overhead account for the new product. For example, assume a new product is being introduced in a company manufacturing high-production automotive assemblies requiring very expensive machinery and cutting tools, expensive buildings, large amounts of electrical power, and a large force of skilled maintenance and inspection personnel. If the new product is a simple device that can be produced with inexpensive machinery and tooling, it would be unfair to saddle this product with the high fixed-overhead charge. Under these circumstances, a wise management will set up a special overhead account for the new product, charging only the actual costs.

When appropriate, try to combine these two approaches, starting with only the variable overhead charge (this automatically eliminates high fixed costs) and then, after production is rolling smoothly, set up and use the special overhead account.

There are other overhead accounts, such as overhead within the engineering department. These costs are often a direct charge on engineering direct labor—especially in a plant accepting contracts to perform specific engineering work. This is done to assure recovery of all costs, both direct and indirect, associated with such work.

In a similar manner, separate or special overhead accounts are often set up for maintenance, toolrooms, test-equipment construction, and similar departments. If the overhead charges in any of these activities are excessive, it may be advisable to secure quotations and examine the idea of ordering some of the work from an outside company.

Selling

This cost element is usually a percentage application against manufacturing costs. Determining size or amount of selling expense can be most difficult. If the new product falls within the product line, it generally simplifies the problem. Usually, expansion of the product line will create two alternatives: Add more company salesmen or use manufacturers' representatives. Cost effect of both courses must be estimated. Manufacturers' representatives normally work on a commission basis; to this must be added company administrative costs and advertising, if the last item is included in selling expense. Advertising is often handled as a separate cost element.

Often the company has several selling organizations and thus has a choice. The associated costs and the probability of successful marketing should be used as criteria in deciding which group to use.

Advertising cannot be ignored since it is necessary to properly support the sales department. While some sales can be achieved without product advertising, its lack is a difficult handicap. However, some help can be expected from existing institutional advertising and/or related-product advertising programs. Such help should be taken into consideration when estimating the cost of advertising. If the new product merely expands an existing product line, it is possible that no additional advertising cost need be considered. However, even in these cases, expansion may necessitate extra promotion costs, especially in the form of literature. Exhibiting at engineering conferences and trade shows is normally considered a part of advertising cost.

General and Administrative

Usually a percentage application against manufacturing cost, little can be done about G and A expense. It normally is a standard charge for a given plant. If the new product can be shown to have little or no effect on the actual magnitude of this cost element, management might be persuaded to forego applying this charge during the initial production.

Patent-License

Sometimes included under G and A expense, patent cost is usually a percentage application against either manufacturing cost or cost of sales (manufacturing plus G and A expense). The new product may not involve any patent-license cost. If this is the case, the product should not be charged with some general percentage which is applied against all products. In some cases, patents obtained by new-product development may actually yield income if license agreements are made with other manufacturers.

Royalty payments are usually determined by ap-

plying the royalty percentage against the sales price of the items sold. Sometimes packaging cost is excluded from the selling price. This latter case slightly complicates the calculations involved in computing the correct percentage to use on the cost-analysis form.

Special Taxes

This cost element usually appears where a state sales tax is involved. It is a tax levied on the selling price. Therefore, like the patent-license royalty rate, it is somewhat difficult to handle. Once the selling price is established, the proper percentage is applied and the dollar amount determined.

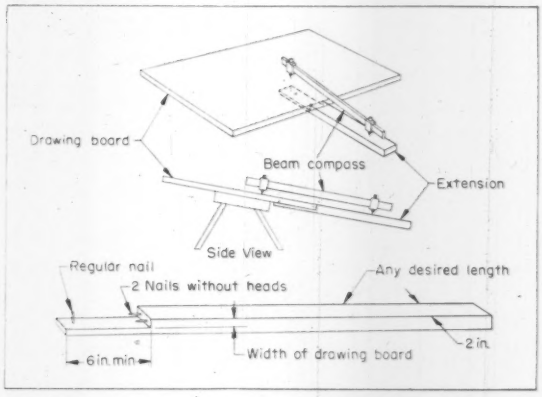
Summary

Costing is a difficult, time-consuming, and tedious process. However, this phase cannot be slighted or a new product has slim chances for success. Engineers working on or with new-product development would do well to familiarize themselves with their company's cost-accounting procedures. Thus equipped, they will find working with accountants and estimators much easier and much more satisfactory.

Tips and Techniques

Beam-Compass Extension

Drawing circles or arcs of large radii sometimes require a center of curvature which is off the drawing board. A beam-compass extension, made of wood

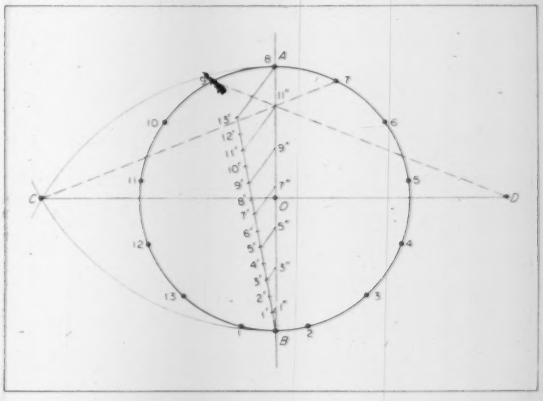


and notched to fit the board, will provide a rigid support for the compass. The extension is attached to the underside and edge board by nails as shown. —Ed Hejtmanek, *Chicago, Ill.*

Dividing a Circle

A circle can be divided into any number of desired parts using these nine simple steps.

1. Draw a circle of any radius *OA*.
2. Extend the radius to make diameter *AOB*.
3. Draw a line from *B* to any point 13′, not on *AOB*.
4. Divide this line *B*13′ into the same number of equal spaces desired for the circle.
5. Connect the last division with point *A* to form line *A*13′.
6. Draw lines from every other point on *B*13′, starting at the top point, parallel to *A*13′, intersecting *AB*.
7. From point *A* using *AB* as a radius, swing arcs to intersect an extended centerline at *C* and *D*.
8. Straight lines drawn from point *C* through the intersection points (1″ through 13″) on line *AB* establish the equal divisions for the right half of the circle.



9. In a similar manner, lines from point *D* through the *AB* intersections establish the equal divisions for the left half of the circle.—Albert Szelle, *Caterpillar Tractor Co., San Leandro, Calif.*

LeRoy Pen Tip

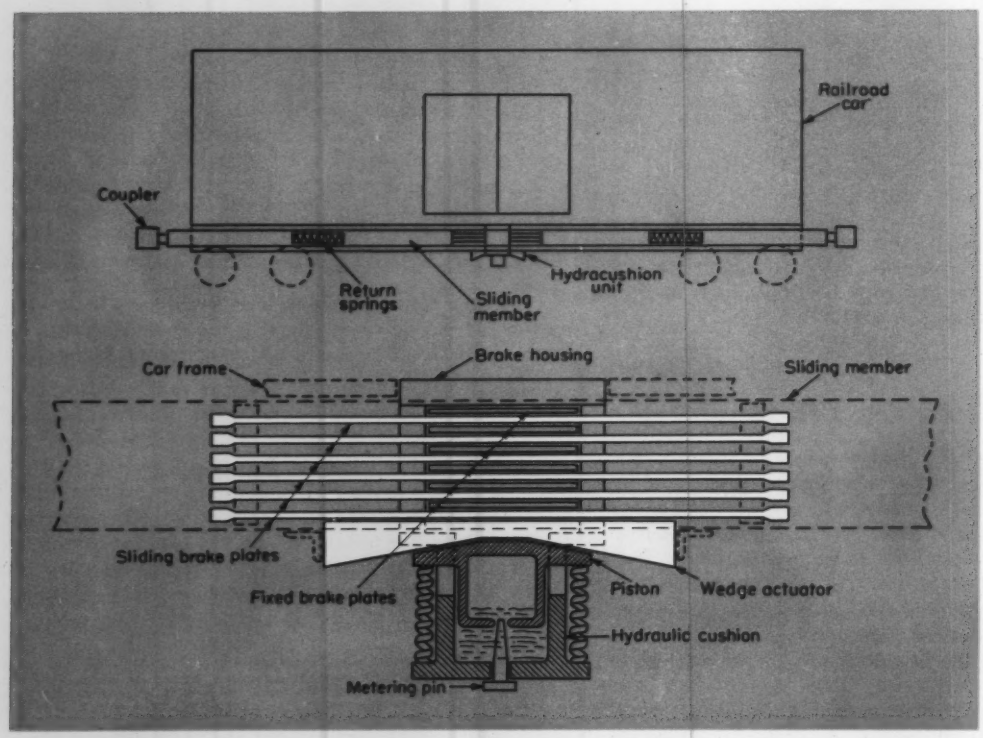
The problem of ink drying in a LeRoy lettering pen when the pen is not in use can be eliminated by setting the pen on a piece of scratch paper so the point is in contact with the paper.—J. R. Cheney, *St. Louis, Mo.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, Machine Design, Penton Bldg., Cleveland 13, O.

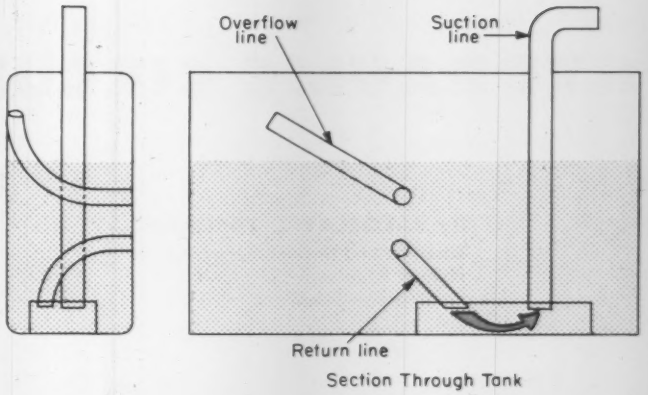
scanning the field for *ideas*

Hydraulic cushioning of braking forces assures smooth dissipation of energy from high-impact stopping loads. The moving member, which is subject to externally applied shock loads, carries a partially floating double-wedge actuator and a group of parallel sliding brake plates; a number of fixed brake plates are located between the sliding brake plates, in line with the piston of a hydraulic cushion. The moving piston of the hydraulic cushion rests on the wedge surfaces.

Upon impact, the moving member forces one of the wedge surfaces against the piston of the hydraulic cushion. A metering pin and orifice arrangement provides a snubbing action to movement of the piston, so that the floating wedge is forced upward into contact with the bundle of moving and stationary brake plates, causing decelleration of the moving member. Due to the action of the hydraulic cushion, the braking of the moving member is accomplished smoothly and uniformly, without sudden shock loads to the stationary structure. The Hydracushion was developed by Stanford Research Institute for use on railroad cars to reduce shock loads transmitted from the couplers to the frame and contents of the car. The system was reported by R. M. Hermes and W. K. MacCurdy in a paper at the 1958 ASME-AIEE Joint Railroad Conference.

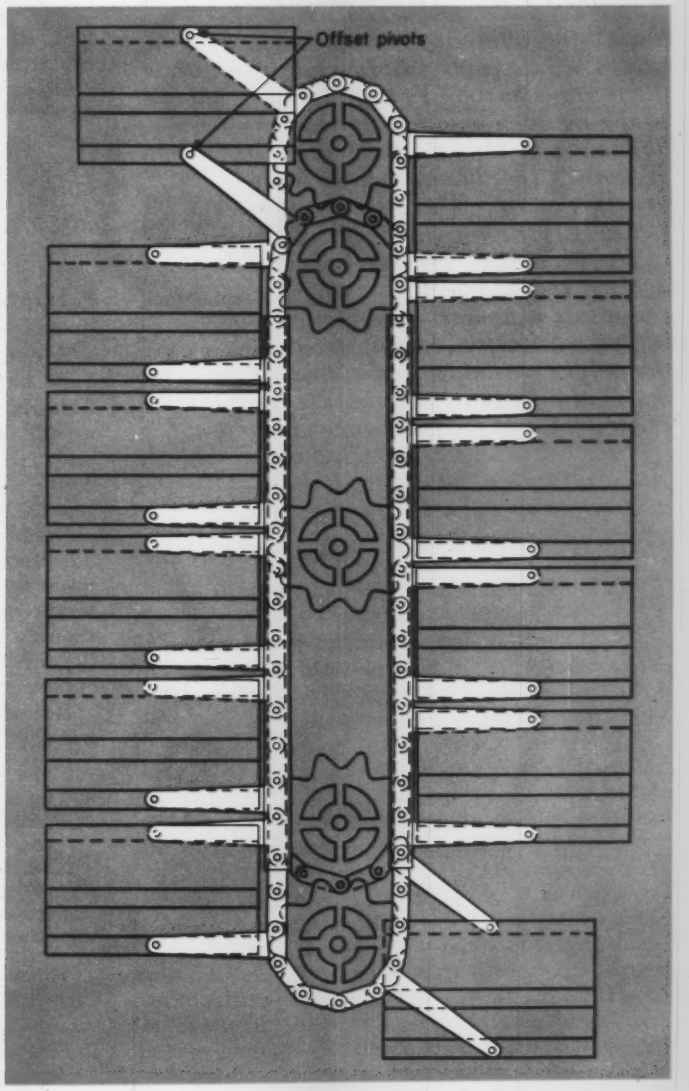


Supercharged hydraulic system provides high operating efficiency with a small reservoir and reduces pressure-surge problems. A channel member is welded to the bottom of the tank on the inside, to form a partially enclosed passage. Both the return and the suction lines are connected to the channel. In operation, high-velocity return fluid is fed into the channel toward the pump suction-line opening. The design provides a pressurized flow of oil to the pump intake without air bubbles or surges. Slots in the side of the channed bleed off excess return pressure, provide additional fluid for pumping, and interchange cool and warm oil during low-demand periods. The design was developed by the Yale Materials Handling Div., Yale & Towne Mfg. Co.

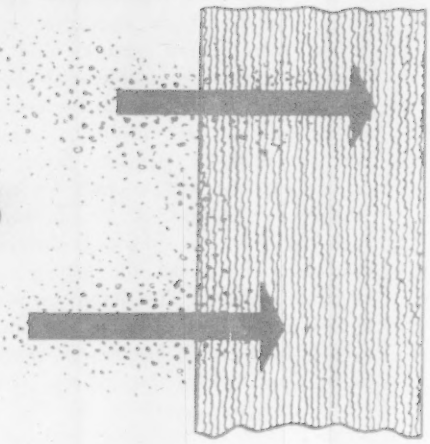


Section Through Tank

Stabilized suspension of moving parts without guides or special linkages is accomplished with a simple offset-pivot arrangement. Each suspended part has two pivot points, located equidistant from the center of gravity of the part. The pivots are on two separate conveyor chains which, with their sprockets, are positioned with a similar offset. As the chains move, the part is carried without swinging or rotation regardless of changes in direction of chain travel. The design was developed by J. W. Mendelsohn, New York, N. Y., for a patented system for storage files.



FILTERING HYDRAULIC CIRCUITS



By JAROSLAV J. TABOREK
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Phillips Petroleum Co.
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There's a dollars-and-cents rule of thumb for selecting hydraulic-system filters: "The finer you filter, the more it costs." Yet fluids carrying even small quantities of abrasives or sludges generate expensive trouble in today's high-pressure, close-clearance components. Obviously, demands for a fluid that is "really clean" must be balanced against requirements for an economical and trouble-free filter installation. In this article, the origin and nature of common hydraulic-fluid contaminants are examined and performance characteristics of filters are spelled out. Two following articles will deal with filter types, selection factors, and application procedures.

EXPERIENCE shows that trouble in a hydraulic system is nearly inevitable whenever the fluid is allowed to become contaminated. Nature of the trouble—whether a simple malfunction, or the complete destruction of a component—depends to some extent on the type of contaminant. Two general contaminant classes can be distinguished: 1. Abrasives, including such particles as core sand, weld spatter, machining chips, and rust. 2. Nonabrasives, including those resulting from oil oxidation, and soft particles worn or shredded from seals and other organic components.

Mechanics of the destructive action by abrasive contaminants are clear. When the size of particles circulating in the fluid-power system is greater than the clearances between moving parts, the clearance openings act as filters and retain such particles. Hydraulic pressure embeds these particles into the softer materials, and the reciprocating or rotating motion of circuit elements develops scratches on finely finished component surfaces. Such scratches lead, in turn, to internal component leakage and decreased efficiency.

Oil-oxidation products, usually called sludge, have no abrasive properties. Nevertheless, sludge also prevents proper functioning of a hydraulic system by clogging up valves, orifices, heat-exchanger coils and filters. It also deteriorates certain essential oil qualities.

Filter or Oil Change?

Frequent changing of hydraulic-system oil is not a satisfactory solution to the contamination problem. Abrasive particles contained in the system are not usually flushed out, and new particles are continuously created as friction products. Furthermore, even minute remnants of sludge act as effective catalysts to speed oxidation of the fresh oil.

Despite reluctance by some system designers to accept the additional cost of filtration equipment, the investment can easily be justified. The initial expenditure for filtration equipment is, as a rule, smaller than the cost of part replacement, particularly when the indirect expenses of down time and the loss of customer confidence are considered.

Use of oil filters has increased in recent years for two chief reasons:

1. The general trend toward higher working pressures. Sensitiveness of circuit elements toward contamination particles is directly proportional to oil pressure. Systems which were perfectly satisfactory at 500 psi will not necessarily operate with the same dependability at 1500 psi.
2. Increased demands for higher dependability and longer maintenance-free life of hydraulic parts.

There are a great many filter types on the market, each justified by some combination of the following essential characteristics: 1. Fineness of filtration. 2. Efficiency. 3. Pressure drop. 4. Pressure resistance. 5. Frequency and ease of servicing. 6. Geometrical

Part 1

- *Contaminants and Their Sources*
- *Filter Performance*

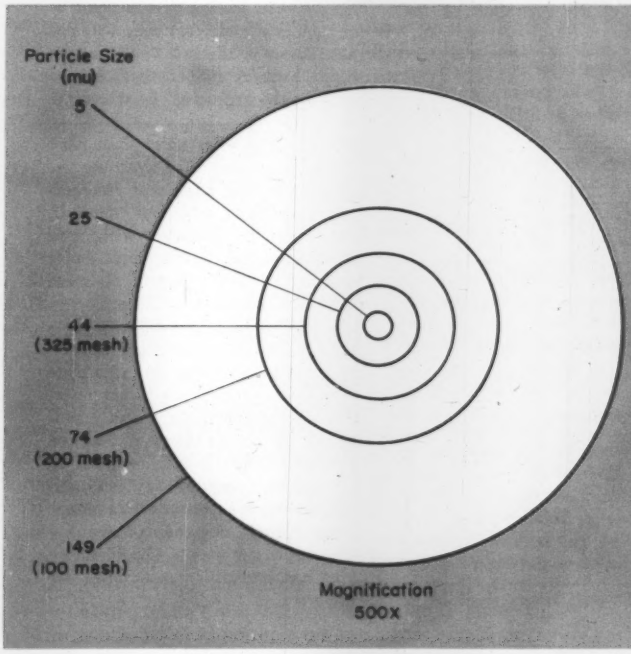
dimensions. 7. Price. The relative importance of these characteristics determines the type of filter selected.

Common Contaminants

The origin of contaminants in fluid-power circuits can be traced to one of four sources: 1. Particles originally contained in the system. 2. Particles introduced from outside sources. 3. Particles created within the system during operation. 4. Particles introduced by foreign fluids. These various contaminant sources are examined in following sections.

Particles Initially Contained in the System: Originating during manufacture and assembly of components, contaminants initially contained in a system are probably the most dangerous because of their abrasive character.

WELD SPLATTER AND SCALE: These particles originate during fabrication of welded circuit components, especially in reservoirs and pipe assemblies. Their presence can be minimized by proper design. For example, seam-welded overlapping joints are preferred, and arc welding of open sections should be avoided. If possible, ample openings that allow final manual cleaning of reservoirs should be provided. However, because particles of this origin have a tendency to adhere strongly to the base metal, they often withstand the usual cleaning methods and are loos-



Sizes of Familiar Objects

Substance	Size (mu)	Size (in.)
Grain of table salt	100	0.004
Human hair	70	0.0027
White blood cells	25	0.001
Talcum powder	10	0.0004
Red blood cells	8	0.0003
Bacteria (avg)	2	0.00008

Unit equivalents:

1 in. = 25.4 mm = 25.4×10^3 mu

1 mm = 0.0394 in. = 1000 mu

1 mu = 0.00004 in. = 0.001 mm

Fig. 1—Relative sizes of particles and comparison of dimensional units. Mesh sizes refer to ASTM Standard woven-wire cloth

ened by fluid pressure and vibration during the run-in period.

MACHINING PARTICLES: Chief offenders in this category originate during thread cutting and in other machining operations that produce hidden or undercut areas which are inaccessible during the usual cleaning and inspection operations. In addition, chips may also be formed during overtightening of pipe-threaded connections. The recently developed O-ring straight-thread fitting should nearly eliminate this source.

CORE SAND: Hidden passages in valve bodies, inaccessible to proper sand-blasting, are the main source of this contaminant type. If the shape of component bodies makes use of hidden passages necessary, an additional bore, which can be plugged later, should be added to permit proper cleaning. However, even the most carefully designed and cleaned castings will almost invariably free some sand particles under the action of hydraulic pressure.

RUBBER PARTICLES: Rubber hose assemblies always contain some loose particles, most of which can be removed by flushing while others withstand cleaning and are freed later by the action of fluid pressures.

PIPE-THREAD SEALING COMPOUND: For minimum contamination, pipe-thread sealing compound should cover only the middle portion of the thread. Use of oil-soluble compounds of low abrasiveness is recommended. Even with the greatest care at assembly, some excess compound almost always enters the system and speeds up oil oxidation. O-ring fittings should also improve this condition.

LINT: While soft lints—for example, from cleaning rags—present no particular abrasion dangers, lint particles have other unwelcome properties. They pack easily into the clearance between O-rings and packings and lead to component leakage and lowered efficiency. They also help clog filters prematurely.

RUST PARTICLES: Rust initially present in hydraulic circuits can usually be traced to improper storage of materials or subassemblies. Particles can range in size from large flakes to abrasives of microscopic dimensions. Complete eliminaton of rust, especially from hidden and inside surfaces (e.g., reservoirs), is difficult because of the atmospheric moisture which condenses during temperature changes. Careful oil spraying or grease coating of offending surfaces is helpful.

Particles Introduced from Outside Sources: Particles from outside sources are introduced into hydraulic circuits at points where either the fluid or certain working parts of the system, for example, piston rods, are at least in temporary contact with the atmosphere. The most common danger areas are at refill and breather openings, and at cylinder-rod packings.

OIL REFILL AND AIR-BREATHER OPENINGS: Contamination arising from carelessness during refilling

JIC Filter Standards

Requirements for filtration on industrial equipment have been spelled out by the Joint Industrial Conference (JIC) in "Electrical and Hydraulic Standards for Industrial Equipment." While the word "filter" is, by popular use, accepted as a designation for any device of particle retaining capacity, the JIC Standards distinguishes two types:

1. Strainers, defined as "devices for removal of solids from a fluid wherein the resistance to motion of such solids is in a straight line."
2. Filters, defined as "devices for the removal of solids from a fluid wherein the resistance to motion of such solids is in a tortuous path."

If this definition were applied to the products currently available, strainers would include wire mesh screens and edge-filter elements, while all other devices would be classed as true filters.

The following paragraphs from the JIC Standards provide further recommendations with respect to filtration and hydraulic fluid cleanliness:

H6.1. Filters

H6.1.1.—Means shall be provided for the continuous removal of deleterious material from the hydraulic fluid which would be detrimental to the operation of the equipment.

H6.1.2.—If the filter is of such design that it will remove antifoam agents or other additives, the type and design of the filter shall be agreed upon between the supplier and purchaser.

H6.1.3.—Self-cleaning filters shall be automatically actuated.

H6.1.4.—Filters shall be of such construction that the filter medium can be removed for cleaning without disturbing the piping. When practicable, suitable means shall be provided to indicate when filter should be cleaned.

H6.1.5.—When suction strainers are provided, they shall be of ample size to strain more than double the intake capacity. Suitable means shall be provided to remove strainers without draining the reservoir.

H6.1.6.—By-pass filters shall be of sufficient capacity to filter the equivalent of all hydraulic fluid in the system within a period of 8 hours.

H6.2.1.—All sealing devices shall be of such materials that they will not be adversely affected by hydraulic fluid. Natural rubber shall not be used with petroleum products.

H5.1.1.—The filler holes shall have a fine mesh screen for straining the oil when filling, fixed with fasteners requiring hand tools for removal, and shall be provided with well fitted caps or covers permanently attached to the reservoir by some suitable means.

H5.1.2.—All reservoirs shall have at least two openings to eliminate pressure buildup while filling reservoir. A breather hole properly protected by an air cleaner shall be provided. The air cleaner shall be of sufficient capacity to maintain approximately atmospheric pressure at maximum demands of the hydraulic system. Combination breather and filler assemblies are preferred.

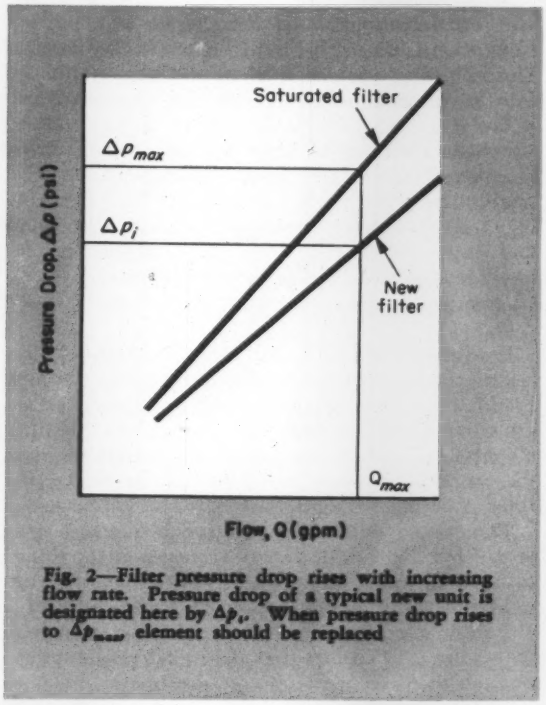


Fig. 2—Filter pressure drop rises with increasing flow rate. Pressure drop of a typical new unit is designated here by Δp_i. When pressure drop rises to Δp_{max}, element should be replaced

can be minimized by proper design. A fine-mesh metal screen, which can be removed for cleaning, is usually placed in the filler opening. This screen will retain all the larger size particles, such as paint flakes and other foreign matter often present in the oil cans of many maintenance shops. The refill opening itself should be provided with a tight cover so that air breathing caused by oil level fluctuations is forced through the proper breather opening.

The breather should be equipped with an air filter of sufficient capacity to handle the air flow corresponding to the fastest possible changes in the fluid volume of the tank. For operation under clean conditions, steel-wool filter inserts are sometimes used, but really good protection against dust intrusion is offered only by paper-cartridge filters which retain all particles above the 40-micron size. If a removable door for tank cleaning purposes is provided, it should be equipped with a gasket to prevent uncontrolled access of dusty air into the tank when the oil level fluctuates.

The chief danger from dust particles is due not to their abrasive action but rather to their tendency to combine with oil foams and oil-water emulsions to form insoluble sludges.

PISTON PACKINGS: If hydraulic-cylinder piston rods are exposed to dusty atmospheres during their outward strokes, dust particles will be drawn into the system. Wiper rings and dust seals are recommended to prevent dust entry at such points.

In systems exposed to extremely dusty or corrosive atmospheres, the full piston-rod length should be enclosed in a bellows-type boot of molded rubber, leather, or impregnated fabric. Such boots prevent accumulation of dirt on the piston rod and protect it from mechanical damage and moisture corrosion.

Contaminants Created Within the System: Contaminants created during system operation are of two general types: 1. Mechanical. 2. Chemical. Particles of mechanical origin are formed by wear of parts in frictional contact, such as in pumps, cylinders, packings, and O-rings. These wear particles can vary in size from large chunks from packings and O-rings, down to steel shavings of microscopic dimensions beyond the retention potential of filters.

The chief source of chemical contaminants in oil is oxidation. These contaminants are formed under high pressures and temperatures, and are promoted by the catalytic action of water and air and of metals like copper or iron oxide. Oil oxidation products appear initially as organic acids, asphaltines, gums, and varnishes, sometimes combined with dust particles as sludge. Oil-soluble oxidation products tend to increase oil viscosity, while insoluble types form sediments and precipitates, especially on the colder elements such as heat exchanger coils.

Oils containing antioxidants have little tendency to form gum under normal operating conditions. However, as the temperature increases, resistance to oxidation diminishes. This explains the importance of keeping oil temperatures below specified levels.

The second contaminant-producing chemical action in hydraulic fluids is their tendency to react with certain types of rubber, causing structural changes in the rubber, turning it brittle, and finally causing its complete disintegration. For this reason, the compatibility of the fluid with O-rings, packing, and hose materials should be checked.

Foreign-Fluid Contamination: Two of the most common foreign-fluid contaminants are water and cutting fluids. Water, which enters even the most carefully designed systems by condensation of atmospheric moisture, normally settles to the reservoir bottom. Oil movement in the reservoir disperses the water into fine droplets, and agitation of the fluid

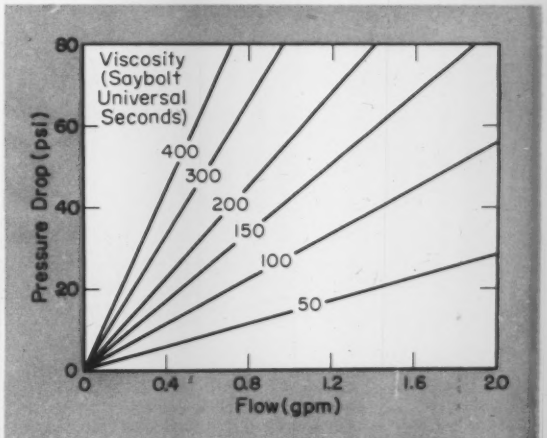


Fig. 3—Typical relationship between flow rate, pressure drop, and viscosity

in the pump and in high-speed passages forms an oil-water-air emulsion. Such an emulsion normally separates out during the rest period in the reservoir, but when fine dust and rust particles are present, the emulsion is catalyzed by high pressures and temperatures into sludge. The damaging action of sludge explains the need for effective filtration, as well as the need for water-separating qualities in hydraulic fluids.

Water contamination in hydraulic fluids also causes rusting of components, particularly during the longer shut-down periods when surfaces normally protected by an oil coating are open to oxidation. The rust formed is in fairly large flakes and is one of the principal sources of fluid contamination. The resulting destruction of fine surface finishes causes, in turn, rapid packing wear. Good hydraulic fluids contain antirust additives which, because of their affinity for metals, form a coating that prevents water from coming in direct contact with metal surfaces.

Cutting fluid is often found in machine-tool hydraulic circuits. Both water-soluble and nonsoluble types have detrimental effects on hydraulic fluids, promoting oxidation and sludge formation in a manner similar to that of water.

Filter Performance

The performance characteristics of the various filters types must be known before a choice can be made. Techniques for performance evaluation have been considerably refined for aircraft and military applications, but lag behind in industrial hydraulics. The following sections spell out what performance data are needed before a filter can be selected.

Particle Size: Size of filter particles, usually given in microns (10^{-3}mm), is the average of the two smallest of the three dimensions of the particles. Fig. 1 shows the relationships of micron, millimeter, and inch units, and gives size comparisons for familiar objects of the same order of magnitude as oil comtaminants.

Pressure Drop: Pressure drop through a filter is directly proportional to the rate of flow through the filter, and limitations on acceptable pressure drop are determined first by the strength of the filter material. To allow for unexpected pressure surges, the working pressure must be set far below the filter rupture strength.

The second criterion for allowable pressure drop is set by the circuit-design requirements. Filters in suction lines, for example, must pass the desired flow with a pressure drop of the order of 1 psi, while pressure-side filters may have as high as 50 psi drop. The fact that the initial pressure drop in a clean filter increases considerably as the filter becomes clogged with contaminants should be considered, Fig. 2.

No generally applicable mathematical relationship between pressure drop and viscosity has been established for filters because of the intricacy of the flow pattern through the porous filter structure.

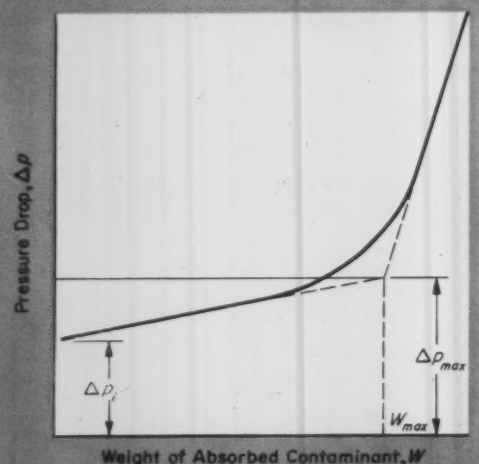


Fig. 4—Pressure drop of a filter rises almost linearly until weight of absorbed contaminant reaches a certain value, W_{max}. Internal filter flow pattern changes at this point, and pressure drop increases at a faster rate. Intersection of the tangents to the two curve sections suggests a value for maximum acceptable filter saturation

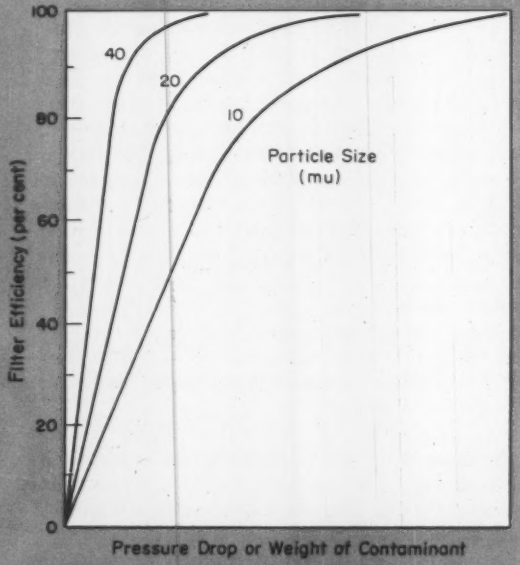


Fig. 5—Filter efficiency rises with weight of absorbed contaminant (or pressure drop). As contaminants accumulate, filter passages clog and larger particles are more easily blocked

Generally, however, pressure drop is directly proportional to viscosity. This is an important consideration when the acceptability of a filter installation is being considered. Pressure drop at the highest expected viscosity should remain below limits set by the structural strength of the filter element.

Typical relationships between pressure drop, flow rate, and fluid viscosity, found experimentally, are plotted in Fig. 3.

Absorption Capacity: Absorption capacity of a filter is defined as the weight of contaminants which the filter will hold and still show an acceptable pressure drop. A typical representation of this characteristic is shown in Fig. 4. Pressure drop is seen to increase with increasing filter saturation until the point is reached where clogging of filter passages changes the internal flow pattern. The curve of pressure drop then bends upward sharply. The suggested capacity rating of the filter is located at the point of intersection of tangents to the two parts of the curve.

With filters of limited absorption capacity, such as the surface type, this characteristic point falls at relatively low absorption values. Depth-type filters, on the other hand, accumulate large amounts of contaminants before clogging, and their transition from one state to the other is not as pronounced.

As a filter becomes saturated, efficiency and fineness of filtration generally increase because pores and internal filter passages become clogged and only particles of decreasing size are permitted to pass. Obviously, this improvement of filtration quality is paid for by a correspondingly higher pressure drop.

The absorption capacity of a filter is a direct measure of the frequency of required servicing, since the larger the amount of contaminant which can be accommodated, the longer the time can be between servicing.

Filter Efficiency: Although filter efficiency has not yet been defined with full clarity, essentially it measures the ability of a filter to retain particles greater in size than a given reference dimension. For example, a filter with an efficiency rating of 99 per cent for particles of 40 mu and over has only 95 per cent efficiency for particles of 10 mu and over, Fig. 5. Efficiency of a filter is also shown in Fig. 5 to increase as the filter becomes clogged with contaminants and the pressure drop rises. Several experimental methods are in common use for evaluating filter efficiency. Representative is the particle-count method, where filter efficiency in per cent is found from

$$E_f = 100\,\frac{n_u - n_f}{n_u}$$

where n_u is the number of particles per unit volume of *unfiltered* fluid which are greater in size than the reference dimension, n_f is the number of particles per unit volume of *filtered* fluid which are greater than the reference dimension.

This test requires microscopic examination of fluid samples, and has the disadvantage of representing the full fluid volume by a limited sample. Also, the difficulty of controlling access of unwanted particles presents a problem. The *Army Standard Air Cleaner Test Dust* (AC Test Dust) is usually used as the standard contaminant. Military specifications call for 98 per cent filter efficiency on a nominal particle fineness of 10 mu.

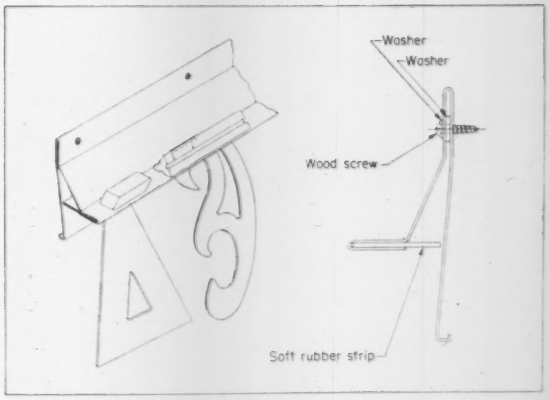
An inherent disadvantage of test based on comparisons of an unfiltered particle count, or an unfiltered particle weight, is that such tests do not take into account the largest particles which pass the filter. Unfortunately, a few particles which are much larger than the nominal filter fineness can seriously damage the system out of proportion to their number. Some filter manufacturers therefore conduct tests to determine the largest particle which will pass the filter. The test is indirect. An air-pressurized filter is immersed in a fluid and pressure is slowly increased until the first bubble passes through the filter. Empirical correlations of air pressure with pore and particle dimensions tell the required particle size. Use of radioactive tracers offers another potential method for evaluating filter efficiency.

The next article in this series summarizes the physical principles of filtration and presents a guide to selection of commercial filter types.

Tips and Techniques

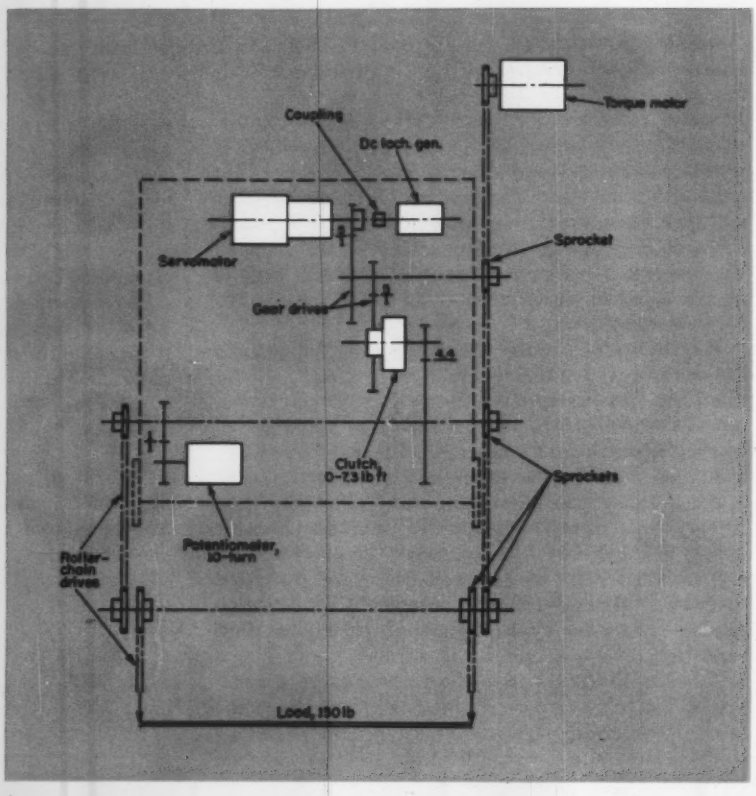
Instrument Holder

A sheet of folded aluminum, with a band of soft rubber inserted along the edge as illustrated, can be used to hold triangles, French curves, and templates. Pencils, rulers, and erasers can be stored on the ledge. — JEAN-PAUL LAMY, *Trois Rivieres, Quebec, Canada.*

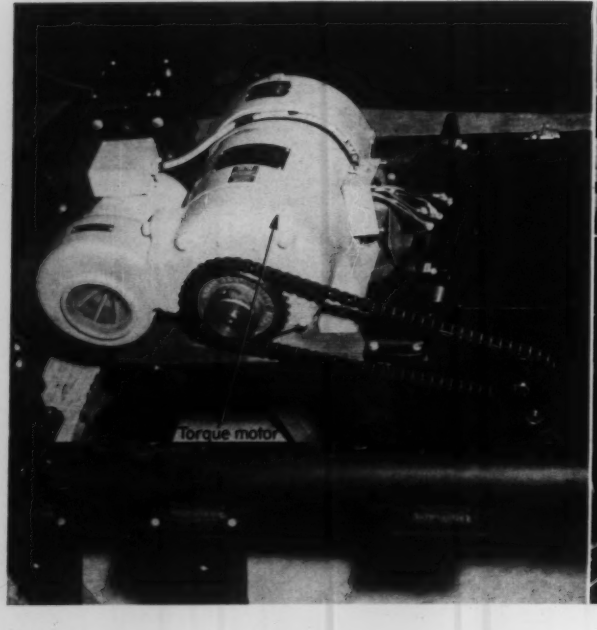


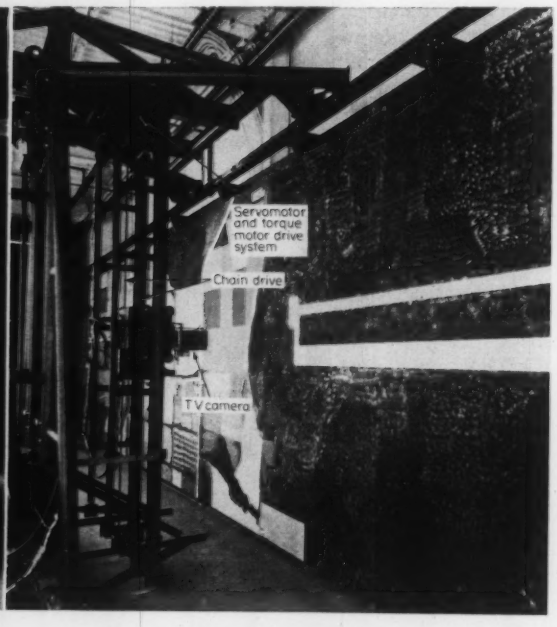
Torque Motor Counterbalances Load

ELECTRICAL DRIVE POWER for vertical positioning of a TV camera is provided by both a servomotor and a torque motor. The 50-w, 400-cycle servo develops only enough power to accelerate the 150-lb camera load and to overcome friction. The 24 lb-in. Wesche torque motor serves as an electromechanical counterbalance.



ROLLER CHAINS raise and lower the TV camera in this DC-8 flight simulator built by Link Aviation Inc. In operation, the television camera is positioned with respect to a terrain model following the simulated flight path and altitude as computed in the flight simulator. The picture picked up is projected on a screen ahead of the pilot trainee, enabling him to make simulated landings and takeoffs utilizing visual cues.



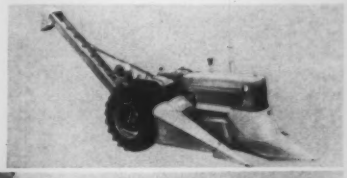


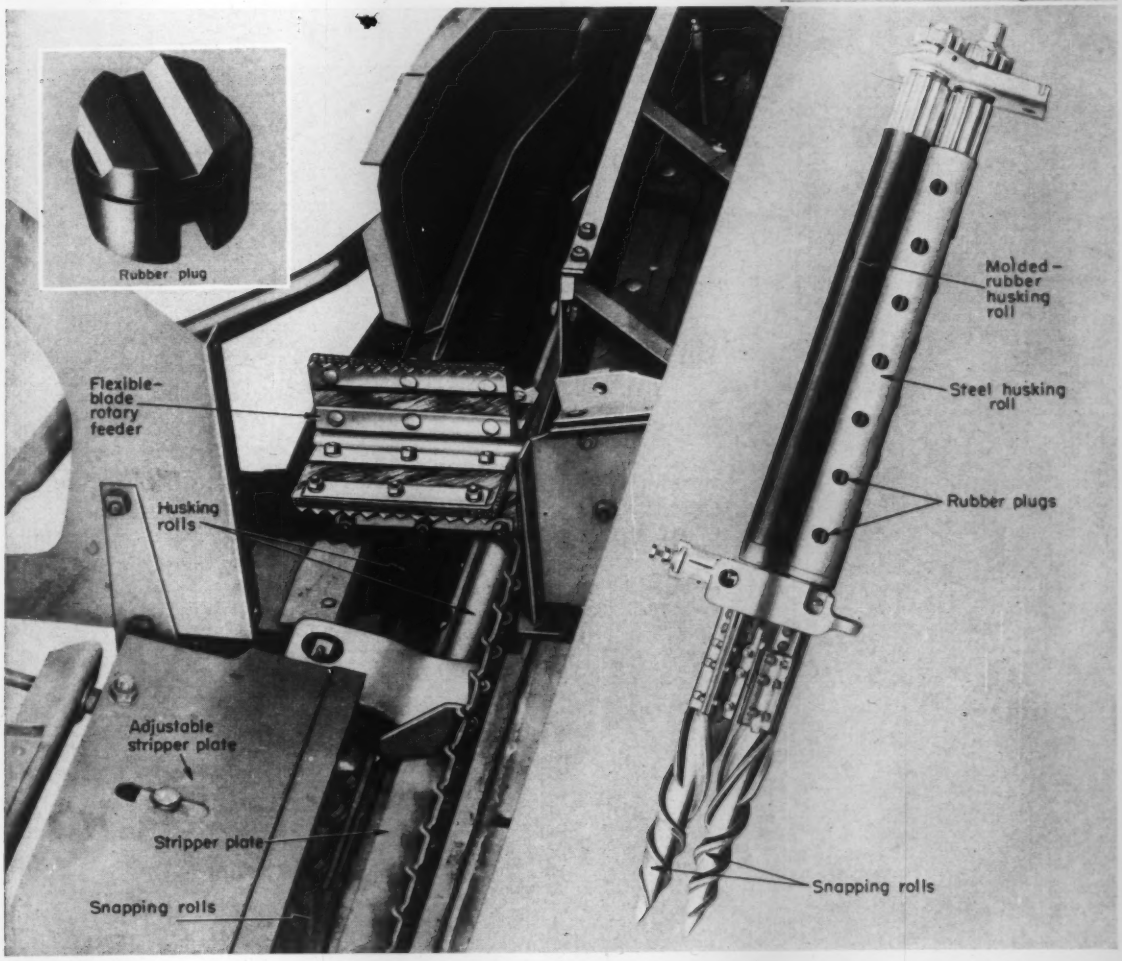
Plugs and Recesses in Rollers Produce Positive Gripping Action

RUBBER-ON-RUBBER ROLLS offer fast, clean removal of corn husks in new Model 17 Allis-Chalmers corn picker. The tractor-mounted, two-row picker is built with four combination snapping-and-husking rolls—a pair on each side. The tapered snapping rolls, which snap the ears from the stalks, are made of steel and can be easily replaced. In each pair of husking rolls, there is one steel roll designed with 26 projecting rubber plugs which mesh with matching recesses in the opposite molded-rubber roll. This novel roller construction grips and securely holds husks as they are stripped from the ears.

THREE-BLADE ROTARY FEEDERS—one above each set of husking rolls—are power driven to maintain steady flow of ears across rolls. These feeders help prevent plugging, speed trash removal, and assure cleaner husking.

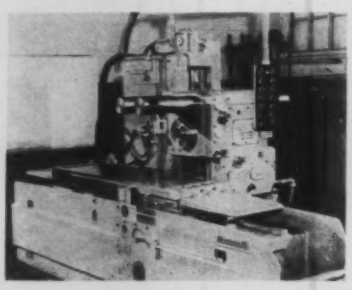
ADJUSTABLE STRIPPER PLATES above snapping rolls control picking capacity and reduce shelling of ears. The opening is lever regulated from the tractor seat to match more closely stalk and ear sizes, which often vary considerably across the length of a field.





Sliding Load Braked by

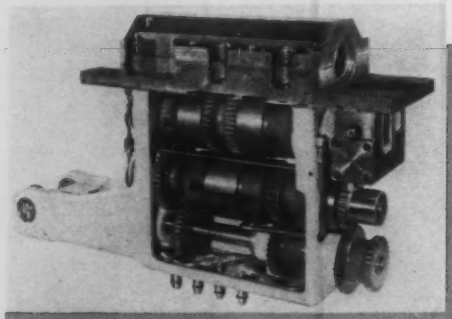
QUICK, PRECISE STOPPING of slides in a new bed-type milling machine is obtained in a transmission using hydraulically interlocked clutches.

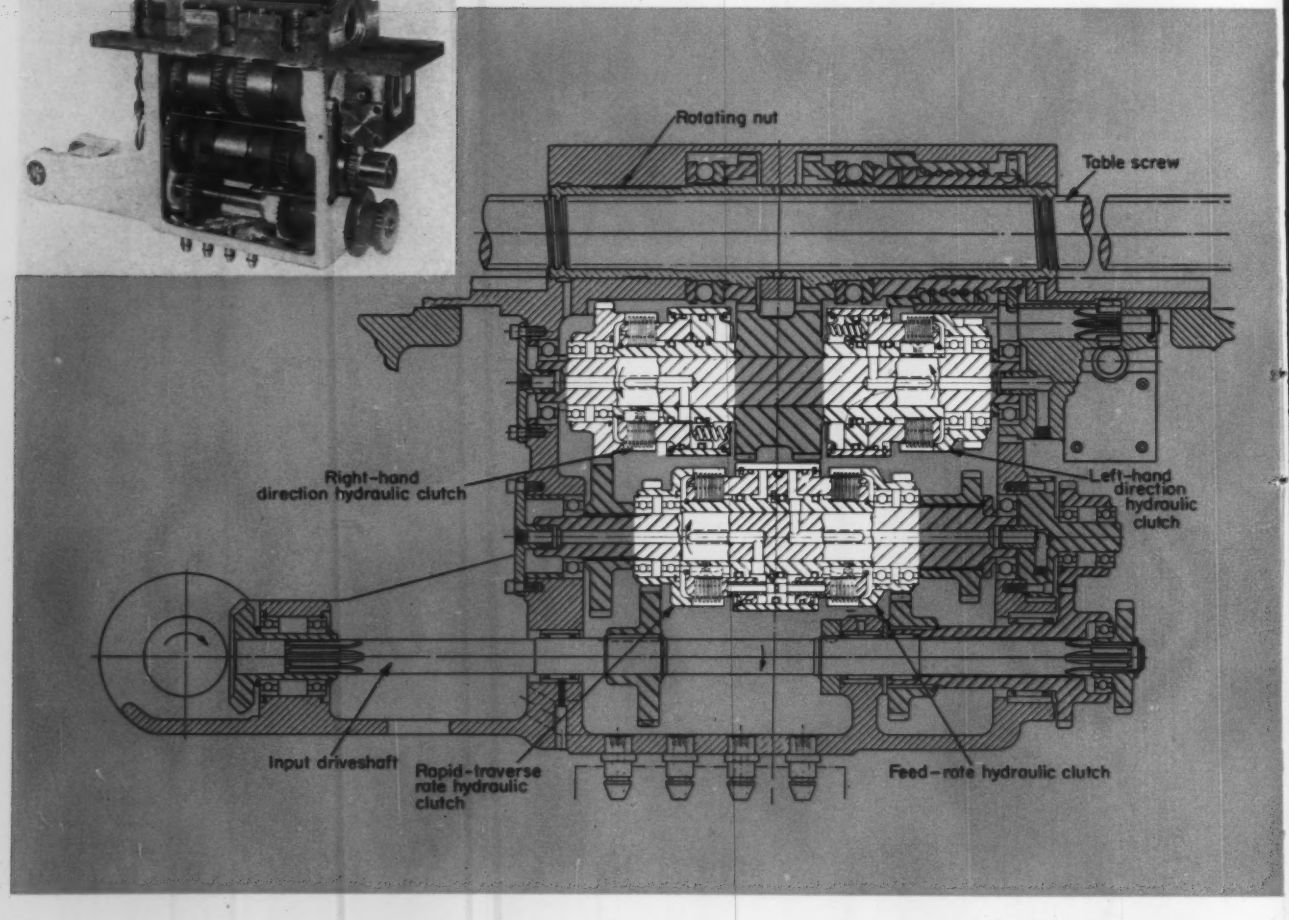


As reported by Frank Zankl, Kearney & Trecker Corp., at the recent Westinghouse Machine Tool Electrification Forum in Buffalo, N. Y., the transmission contains a special nut which rotates on a fixed table screw. The rotating nut is, in turn, connected to the direction-clutch power shaft through gears.

Two hydraulic clutches (right and left-hand rotation) drive this power shaft in opposite directions. When the table is not moving, both of these direction clutches are energized, but the drive to them from the feed clutch or rapid-rate clutch is not energized. When a coasting or overhauling load from the table tends to rotate the nut, the nut can turn only if it causes one of the two direction clutches to slip. Therefore, the direction clutches form an effective brake.

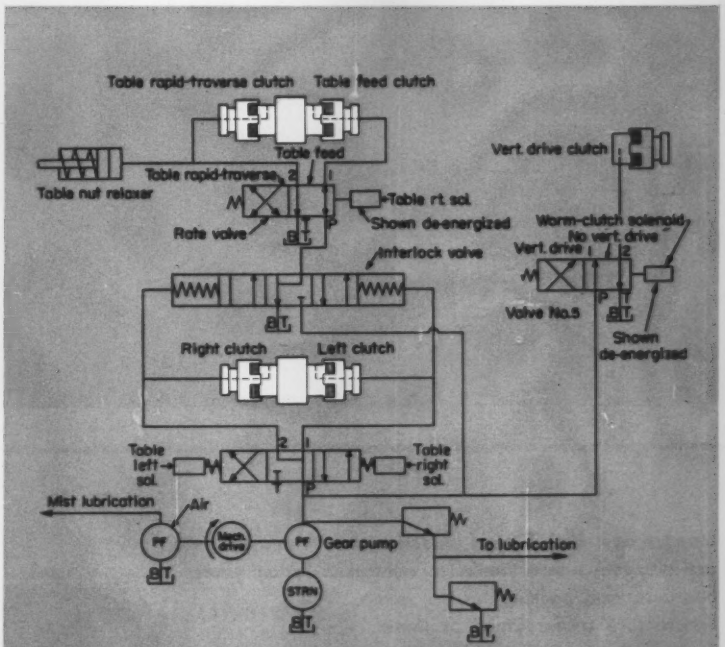
To move the table in a desired direction at a particular rate, either the right or left-hand direction clutch is de-energized. Then either the feed or rapid-traverse clutch is energized, permitting the table nut to rotate and move the table.



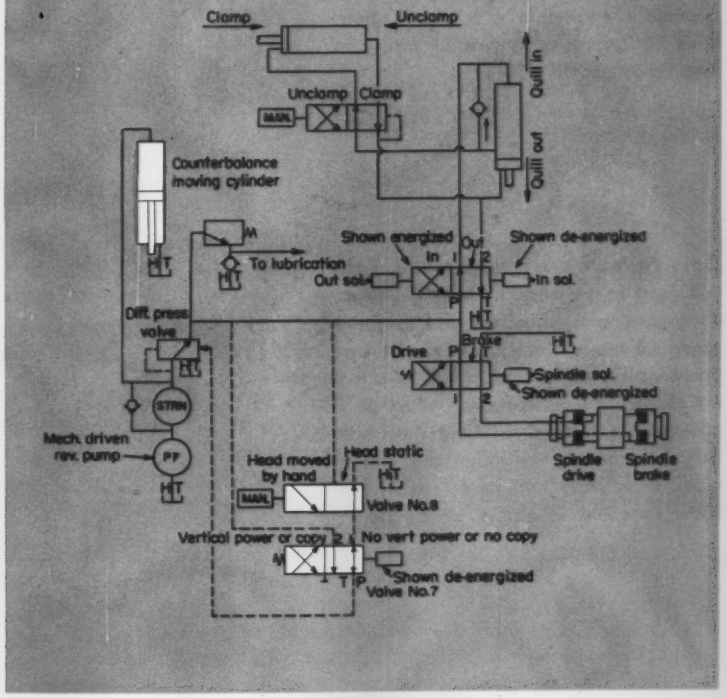


Opposed Hydraulic Clutches

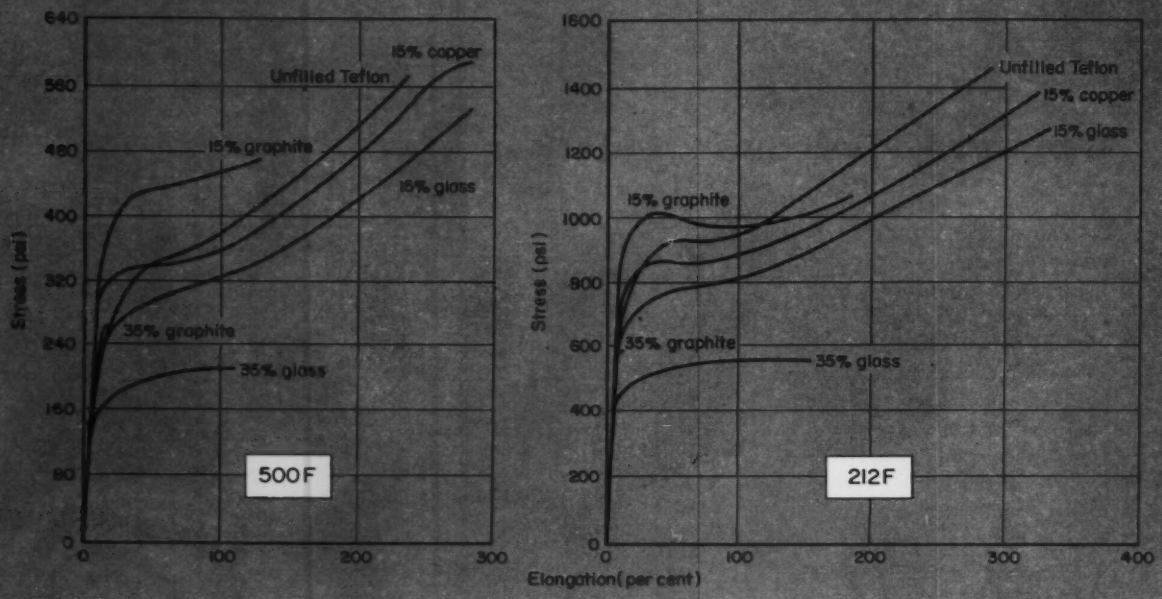
HYDRAULIC INTERLOCKING of the system is accomplished as follows: The hydraulic pump routes fluid under pressure through the neutral position of the left-right direction valve and then to both right and left hydraulic clutches. This causes both right and left hydraulic direction clutches to be energized. Therefore, the interlock valve must move to the central position and make flow to the rate valve impossible, causing both feed and rapid-traverse hydraulic clutches to be disengaged. Under these conditions, with both direction clutches energized, it is impossible for the table drive nut to move the table without causing one or the other of these clutches to slip.



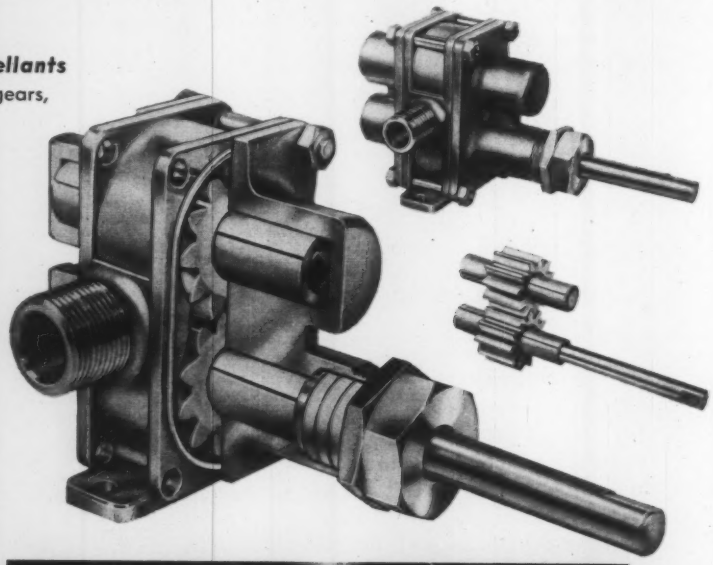
HYDRAULIC COUNTERBALANCE system permits a hydraulic motor of reasonable size, pressure, and fluid displacement to raise the 3000-lb milling head. The head is always counterbalanced to at least 50 per cent of its weight. When vertical movement occurs, the head is counterbalanced to at least 80 per cent of its weight. This action is controlled by valves No. 7 and 8.



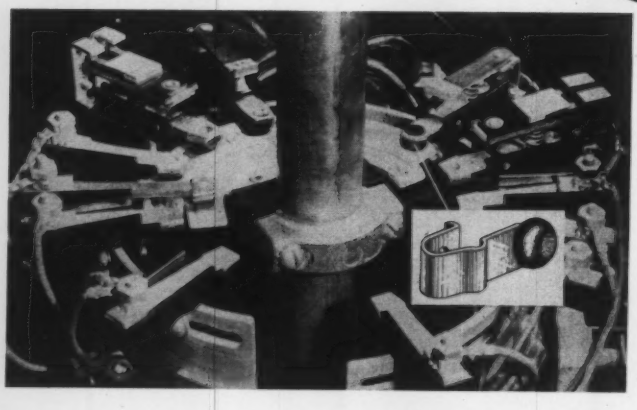
Tensile strength of unmodified and filled Teflon (Fig. 1)

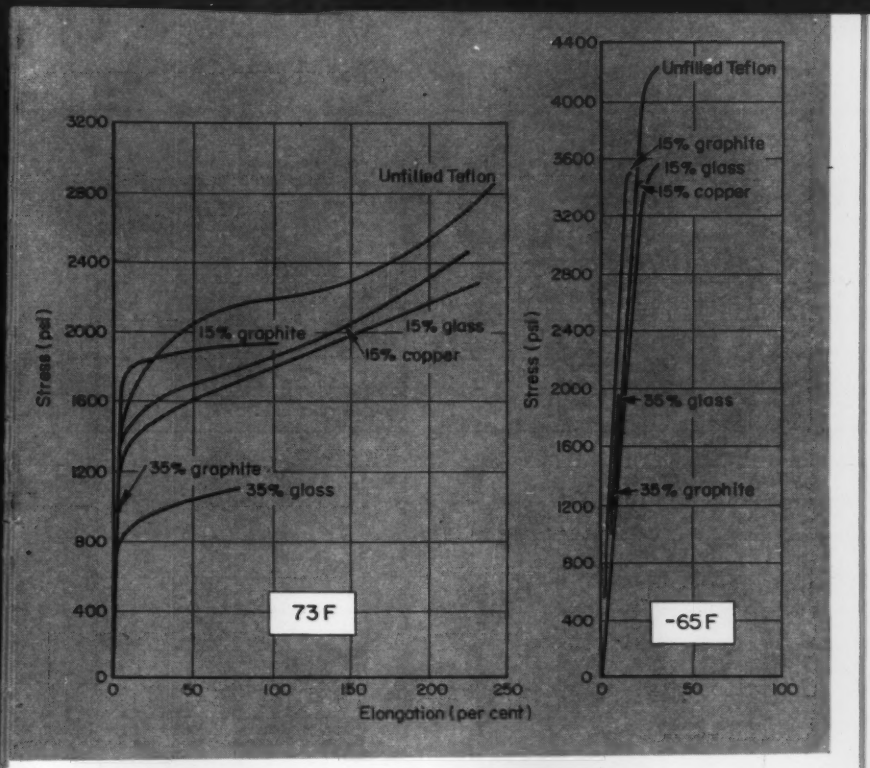


Dangerous fluids and missile-grade propellants are pumped safely thanks to reinforced-Teflon gears, bearings, and packings in this pump. Satisfactory performance of these components is not possible with unmodified TFE resins. Temperature rating of the pump far exceeds the 180 F maximum previously attainable with plastic gears since Teflon resins are rated for continuous use to 500 F.



Cam followers of reinforced Teflon are used in switches to activate elevator door-opening mechanisms and to control speed of the elevator. Toughness and abrasion resistance make Teflon a natural for the job. Cam followers show no appreciable wear after more than half a million cycles of operation, are more quiet than other materials tested, and show excellent insulating properties.





Filled TFE fluorocarbon plastics promise to open whole new fields of application in which the mechanical, electrical, and chemical properties of the compound are tailored to job requirements. Here for the first time are data supplied by DuPont which show how certain fillers or additives improve the properties of these plastics.

Properties and applications of

REINFORCED TEFLON

By FRANK M. CHAPMAN
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Wilmington, Del.

PERFORMANCE of TFE fluorocarbon resins is improved considerably by use of fillers. Such modification affects certain mechanical properties and permits resin-filler compositions to be tailored to the requirements of a wide variety of mechanical, electrical, and chemical applications.

In general, TFE resins can be compounded to increase:

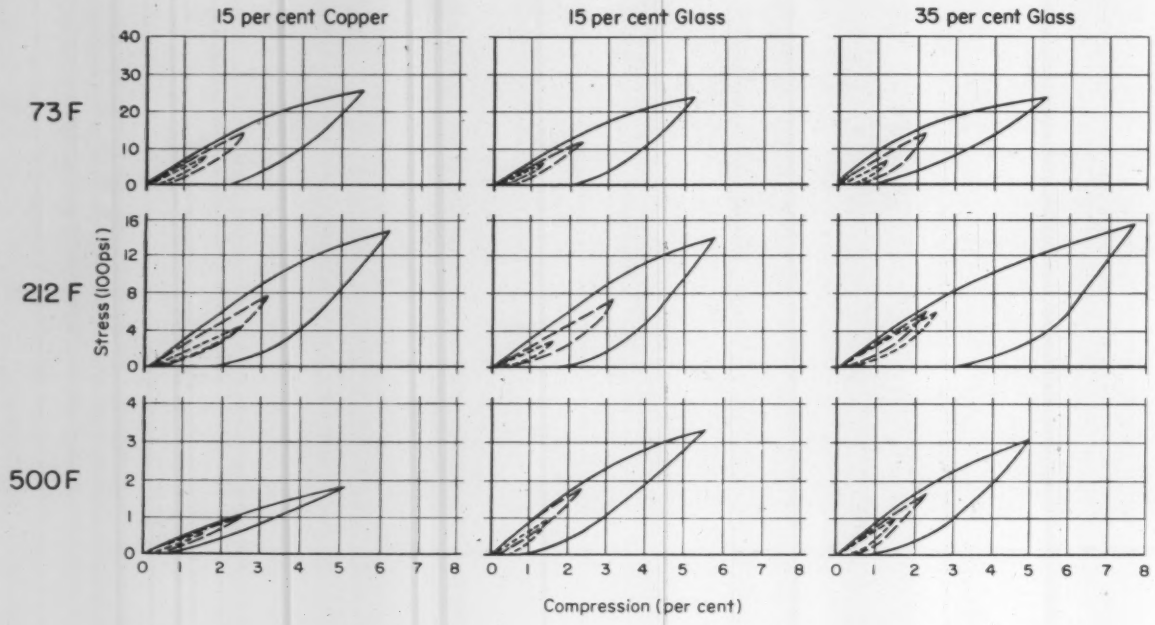
1. Resistance to initial deformation under load by approximately 25 per cent.
2. Resistance to rotating-shaft wear by as much as 500 times.
3. Stiffness by a factor of 2 to 3.
4. Thermal conductivity by a factor of 5.
5. Resistance to creep approximately twofold.
6. Thermal dimensional stability by a factor of 2.
7. Hardness by approximately 10 per cent.

Further, modified compositions retain the desirable properties of uncompounded Teflon.

Use of reinforcing agents in Teflon has been the subject of extensive investigations during the past few years by Du Pont. To date, sufficient data on filled Teflon have been accumulated to assist the design engineer in determining where and how these modified resins may be best used. This article discusses the physical properties of various filled compositions at temperatures from −65 to 500 F and describes the general effect of the addition of fillers to resin. It supplements the series of four articles on "Designing with Teflon" published in MACHINE DESIGN, September 5 and 19, and October 3 and 17, 1957, issues.

Filler Materials: Any material which can tolerate processing temperatures of 700 F can be used as a filler. This temperature requirement eliminates or-

Fig. 2—Compressive and recovery characteristics of unmodified Teflon and filled compositions at 73 to 500 F (ASTM D-695-54, mod.). Moldings of filled TFE resins become more resistant to deformation with repeated loading



ganic additives, but most inorganic materials are sufficiently heat stable. Suitable fillers or reinforcing agents include metallic copper and bronzes, glass fiber, ceramic fibers, graphite, coke flour, molybdenum disulfide, clay, talc, silica, asbestos, and calcium fluoride. Data presented here concern glass, graphite, and copper fillers, Table 1. Teflon 1 was mixed with a filler by grinding at low temperatures attained with liquid nitrogen. Test specimens were cut from molded sheets $\frac{1}{8}$ in. thick which were free-baked at 720 F for $1\frac{1}{2}$ hr and cooled at a rate of 120 deg per hr. Table 1 shows preform pressures.

At high loadings, void content of the compound tends to increase, which adversely affects certain properties. This is particularly true for the 35 per cent graphite composition. However, improvements in fabrication techniques will correct this.

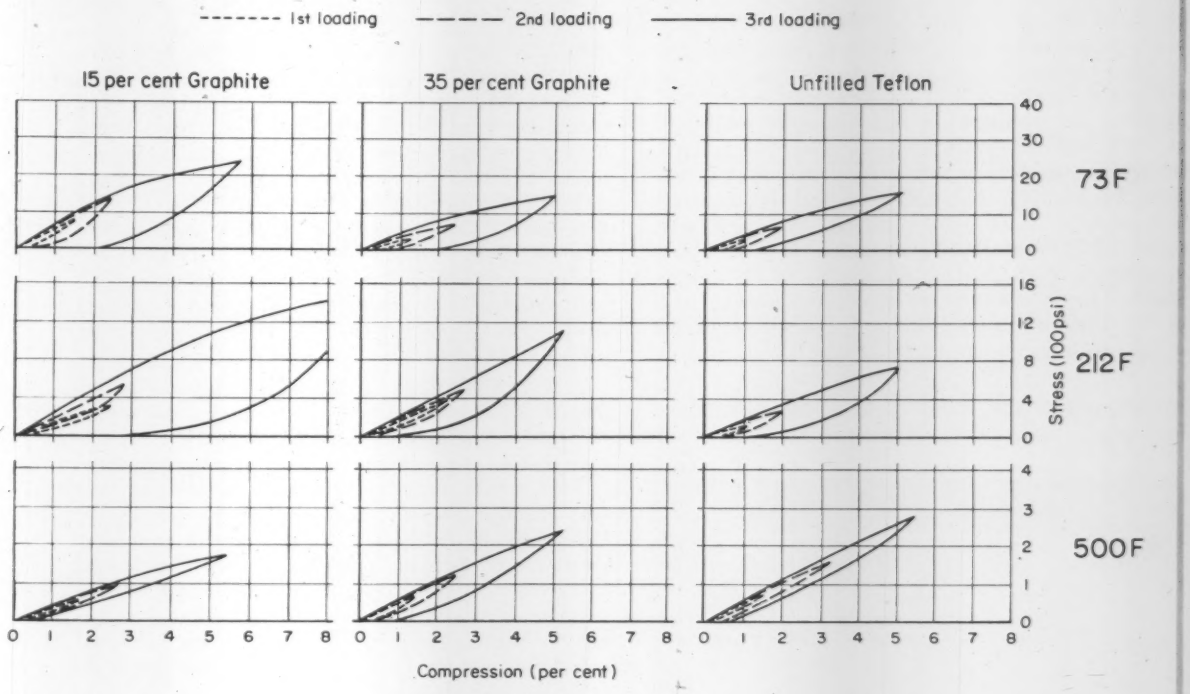
Other Reinforcing Materials: Metal or glass fabric and glass and ceramic fibers are also used to reinforce Teflon resins. Mechanical properties of the resin are greatly improved by proper orientation of fibers. Yarns of TFE-resin fibers have a tensile strength of 50,000 psi and a corresponding increased resistance to deformation. Combinations of glass-fabric reinforcement and TFE resin give structures that have excellent physical properties, high stiffness and abrasion resistance, and outstanding ability to withstand mechanical abuse.

Material reinforced with glass fabric is dimensionally stable, and its resistance to deformation under compressive load is equivalent to that of the fabric itself. Flow under combined heat and pressure is also extremely low. Frequently, TFE fluorocarbon resins are reinforced with metal which provides a structure with the low-friction and nonadhesive characteristics of TFE resins and the strength of the metal.

Yield Strength: Yield point is often used as an indication of the maximum stress that can be sustained by a material under a specified type of loading without plastic deformation. However, some materials,

Table 1—Compositions and Filler Materials

Filler	Amount (% by vol)	Type and Density (grams per cc)	Preform Pressure (psi)	Density of Molded Sheet (grams per cc)	Volume of Filler, Actual (per cent)	Void Content (per cent)	Crystallinity (per cent)
None	..	.....	4,000	2.16	None	0.4	55 to 57
Glass	15	1/32 in. milled fiber, d=2.55	20,000	2.17	13.1	2.2	55 to 57
Glass	35	1/32 in. milled fiber, d=2.55	20,000	2.13	31.4	6.9	55 to 57
Graphite	15	200 mesh, d=2.23	20,000	2.13	14.7	2.3	55 to 57
Graphite	35	200 mesh, d=2.23	30,000	1.86	34.3	12.5	55 to 57
Copper	15	325 mesh, d=8.92	20,000	3.00	15.1	5.8	55 to 57



including the TFE fluorocarbon resins, do not exhibit a yield-point phenomenon. For these materials, yield strength, or apparent elastic limit, is the closest comparable property.

For materials that do not exhibit a yield point and significant proportional limit, modulus of elasticity is not a constant proportionality. Test data reported herein are in the form of stress-strain curves which enable the design engineer to better understand the mechanical utility of the resin.

Tensile Strength: Tension tests, properly interpreted, provide reasonably accurate information of how parts made of TFE resins will behave under conditions which the tests approximate and are also useful for quality control. Tensile-property data show that, except for the 35 per cent glass or graphite specimens, filled compositions can be recoverably deformed at least 10 per cent, Table 2. Values of yield strength at 10 per cent strain are also shown. Tests were made in accordance with ASTM D-1457-56T, a modified procedure for ASTM D-638-56T.

Transitions of TFE resins cause the stress-strain curves at various temperatures to have different shapes, Fig. 1. Low tensile properties of the 35 per cent graphite composition might be explained by the inherently high void content of sheets molded from this material.

Flexural Modulus: As with the tensile and com-

Table 2—Tensile Characteristics*

Temperature (F)	Filler	Amount (% by vol)	Tensile Strength (psi)	Ultimate Elongation (per cent)	Yield Strength (psi)
−65	None	..	4210	21	2100
	Glass	15	3560	21	1800
	Graphite	15	3550	12	3000
	Copper	15	3410	16	2100
	Glass	35	1820	8	Break
	Graphite	35	1250	6	Break
72	None	..	2790	236	1600
	Glass	15	2300	234	1400
	Graphite	15	1940	100	1800
	Copper	15	2450	229	1500
	Glass	35	1100	79	850
	Graphite	35	973	3.6	Break
212	None	..	1470	278	700
	Glass	15	1280	318	650
	Graphite	15	1060	171	850
	Copper	15	1430	311	750
	Glass	35	543	144	450
	Graphite	35	587	5	Break
500	None	..	575	236	220
	Glass	15	527	279	220
	Graphite	15	467	130	280
	Copper	15	592	283	280
	Glass	35	212	108	160
	Graphite	35	257	11	250

*2 in. per min draw rate on specimens 1½ in. long by 0.187 in. wide.

Table 3—Flexural Modulus*

Filler	Amount (% by vol)	At −65 F	73 F	212 F	500 F
None	..	218,000	80,700	28,700	6,500
Glass	15	363,000	166,000	65,800	15,500
Glass	35	332,000	208,000	113,000	25,900
Graphite	15	276,000	126,000	61,000	16,300
Graphite	35	320,000	162,000	76,000	27,200
Copper	15	320,000	156,000	61,200	20,700

*In psi.

pressive properties of TFE resins, relationship of flexural stress to strain is not linear beyond a few pounds loading and the modulus cannot be used satisfactorily for higher loads. Measurements of flexural modulus are useful for determining relative stiffness of filled compositions at low and elevated temperatures, and effects of filler content. Relative stiffness of filled compositions at temperatures from −65 to 500 F is shown in Table 3. As would be expected, flexural modulus increases with filler content, particularly at high temperatures, and is relatively independent of the reinforcing agent. Sheet specimens, ½ in. wide by ⅛ in. thick, were tested in accordance with ASTM D-790-49T over a 2-in. stand. They were centered under the loading nose of an Instron compression cell plate and loaded at the rate of 0.05 in. per min.

Compressive and Recovery Characteristics: Moldings made from filled TFE resin were loaded in compression at a relatively low, uniform rate of strain at various temperatures. Behavior of these moldings is quite different from that of the elastomers but approximates to a degree that of soft metals. At high temperatures, their behavior is similar to that of filled-rubber compositions. These characteristics are important in sealing, bearing, and supporting applications. Data on compressive stress, deformation or strain, compressive strain, elastic modulus, and recovery were obtained for strains up to 5 per cent for various additives and fillers, Fig. 2. Specimens 1 in. square by 1 in. thick were stacked to a height of 1 in. on the Instron compression cell plate and loaded at a rate of 0.05 in. per min. This was repeated for approximately 1, 2, and 5-per cent strains. Data show the effect of repeated loadings on deformation which simulate a cycling condition.

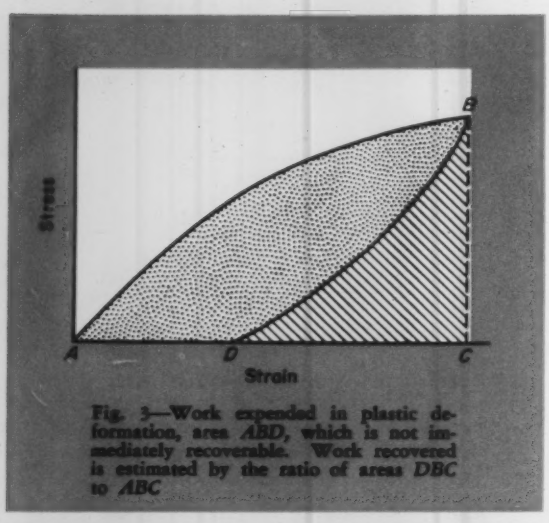


Fig. 3—Work expended in plastic deformation, area *ABD*, which is not immediately recoverable. Work recovered is estimated by the ratio of areas *DBC* to *ABC*

Moldings of filled TFE resins subjected to repeated loading actually become more resistant to deformation. A greater stress is required on the second loading to reproduce the original strain than is required on the first loading. It is believed that this effect is due to strain hardening, much like that observed in metals. In a typical compressive stress-strain plot, Fig. 3, work recovered is estimated by the ratio of areas *DBC* to *ABC*. Area *ABD* represents work expended in plastic deformation or orientation. This energy is, therefore, not immediately recoverable, but may be recovered in part at least with time or with heat.

These data are based on test samples that were essentially unconfined. However, with a thin-walled, single sheet and in gasket recesses, a pronounced wall effect which retards plastic deformation can be expected to provide greater work recovery and considerably less deformation.

Creep Characteristics: To show how fillers reduce creep, consider a low-friction supporting bearing of TFE resin filled with 15 per cent glass under

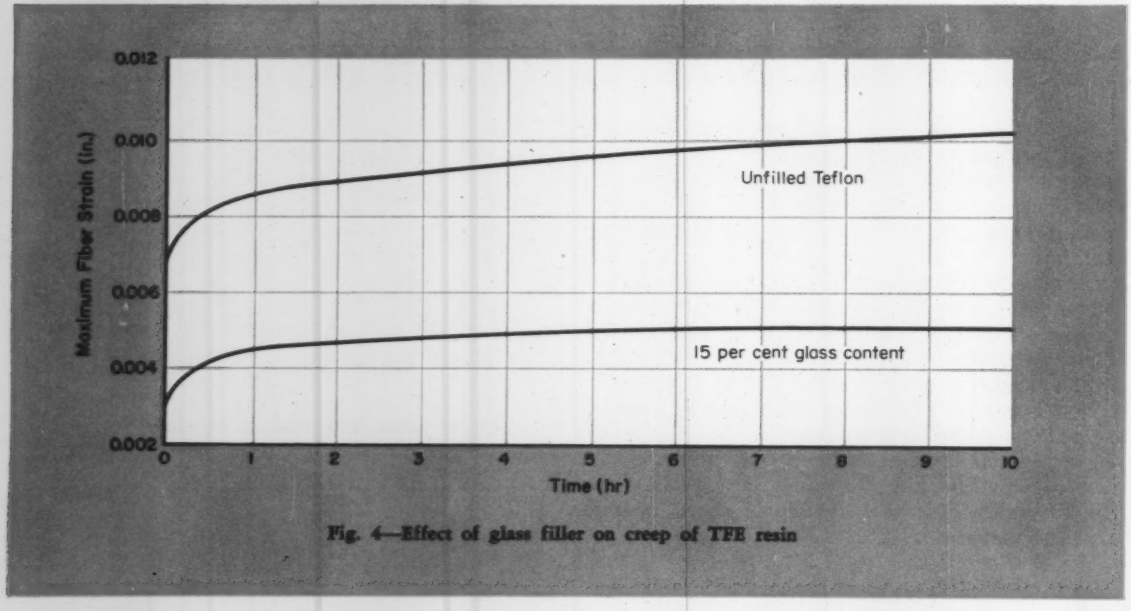


Fig. 4—Effect of glass filler on creep of TFE resin

a 500-psi load at 78 F, Fig. 4. There is zero fiber strain before loading; a 0.003-in. maximum fiber strain is induced when the load is applied; total strain increases to 0.0052 in. at the end of 10 hr, and to 0.0075 in. at 1000 hr. Creep from 10 to 1000 hr is about the same as that which occurs in the first 10 hr. For practical purposes, change in creep after 1000 hr of sustained load is negligible.

Fig. 5 compares creep characteristics of unmodified and filled TFE resins at various stress levels from −65 to 500 F. Since flexure involves a combination of tensile and compressive stresses, maximum strain in the outermost fiber is used to predict creep in compression and tension at low strains. There are certain deviations in creep data for compositions with high loadings, particularly at −65 and 73 F. These deviations are not yet well understood, but may be due in part to the high void content and/or certain transitions that occur in this temperature range.

Thermal Properties: Linear thermal expansion of TFE resins is lowered considerably by addition of inorganic additives. Coefficients approaching those of aluminum and bronze, or about double that of a mild steel, are obtained by adding 35 per cent glass. Thermal expansion depends on the coefficient of expansion of the additive and amount of filler added. Fig. 6 compares linear thermal expansion for various filled compositions from −60 to 450 F. Thermal expansion of a 15 per cent glass compound is about half that of unmodified TFE.

Fiber reinforcements, such as glass filaments or coated glass fabric, reduce thermal expansion of the compound (along the plane of the fibers) to a value almost equal to that of the reinforcing material. This results in an anisotropic expansion with,

Table 4—Thermal Conductivity

Filler	Amount (% by vol)	Thermal Conductivity (Btu/hr/sq ft/deg F/in.)
None	..	1.7
Coke flour	66.7	6.6
Graphite	50	9.5
Graphite	74	19.5
Asbestos	50	4.2
Copper	50	7.5

Table 5—Coefficient of Friction

Filler	Amount (% by vol)	Speed→ Load →	Static 4000 lb	250 fpm 20 lb	100 fpm 25 lb
None	..		0.022	0.32	0.07
Glass	15		0.024	0.35 to 0.44	0.05 to 0.12
Glass	35		0.036	0.38 to 0.46	0.06 to 0.10
Graphite	15		0.023	0.35 to 0.48	0.04 to 0.08
Graphite	35		0.035	0.14 to 0.37	0.06 to 0.08
Copper	15		0.036	0.19 to 0.31	0.09 to 0.12

Table 6—Armstrong Abrasion Test*

Filler	Amount (% by vol)	Thickness Loss (mils)
Copper	15	7.8
Graphite	15	10.8
Glass	15	12.3
Glass	35	14.4
Graphite	35	16.4
None	..	11.4

*Abradant No. 320, 15-lb load at 200 cycles.

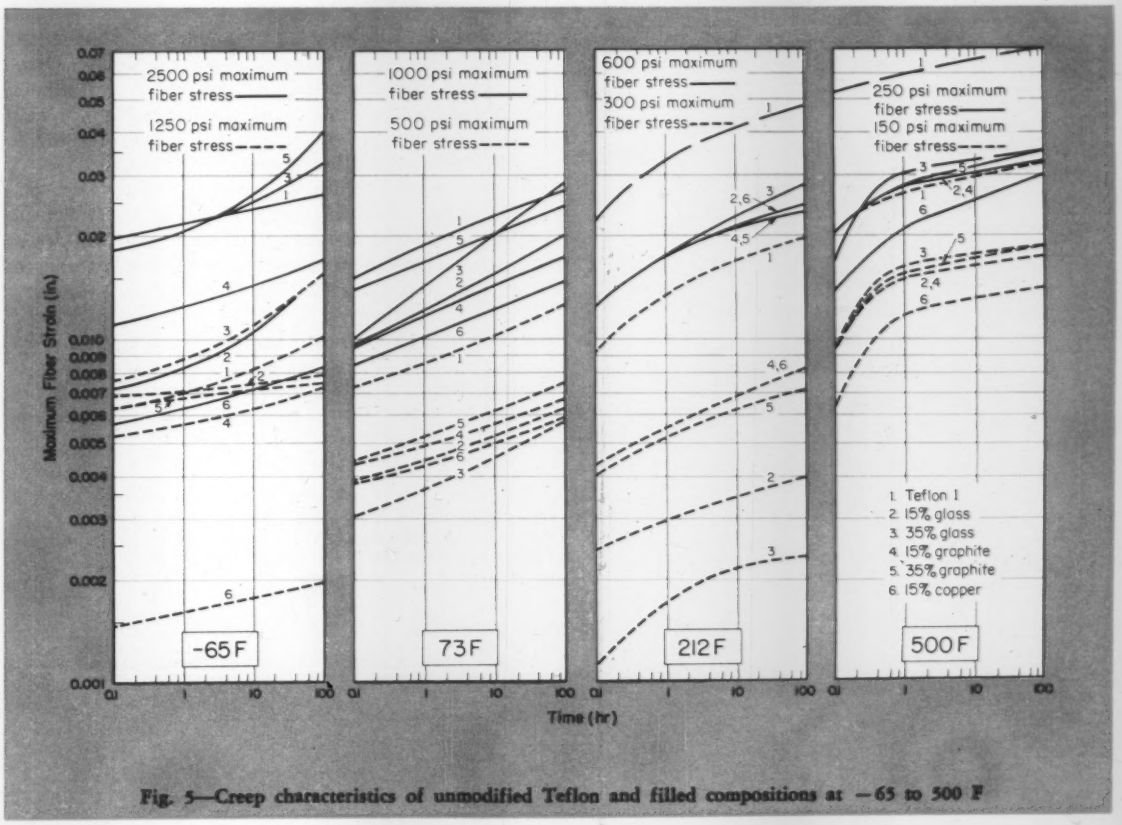


Fig. 5—Creep characteristics of unmodified Teflon and filled compositions at −65 to 500 F

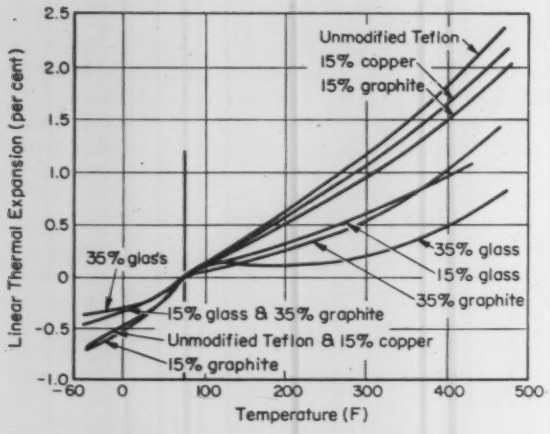


Fig. 6—Linear thermal expansion of unmodified Teflon and filled compositions. Thermal expansion of a fiber-reinforced compound is reduced to a value close to that of the reinforcing material itself

Table 7—Taber Abrasion Test, Weight Loss*

Filler	Amount (% by vol)	At 10 cycles	50 cycles	100 cycles	500 cycles	1000 cycles	2000 cycles
None	..	0.35	1.65	2.2	5.7	8.9	13.4
Glass	15	3.4	7.6	9.3	15.2	19.3	25.7
Glass	35	8.2	17.3	22.3	38.7	50.9	66.0
Graphite	15	0.8	2.2	2.7	5.9	8.6	12.9
Graphite	35	3.3	7.9	11.6	27.2	38.3	52.7
Copper	15	1.7	4.5	8.2	19.0	26.1	36.3

*In mg.

Table 8—Sleeve-Bearing Test

Filler	Amount (% by vol)	Wear (mg per hr)	Condition
None	..	200	1 by ¾-in. ID stainless-steel shaft (410), 60 fpm under 42-lb load.
Graphite	25	0.7	
Glass	22	0.2	
Copper	25	1.2	
Graphite	25	0.7	1 by ¾-in. ID stainless-steel shaft (410), 215 fpm under 21-lb load.
Glass	22	0.4	
None	..	0.74	½ by ¼-in. ID stainless-steel shaft (303), 9.5 fpm under 250-lb load.
Graphite	15 to 25	0.0015	
Glass	15 to 25	0.0015	
Copper	4 to 8	0.032	

		Wear (mg per hr) 0 to 4 hr	4 to 150 hr	
None	..	283.5	Not run	1 in. diam mild-steel shaft with 1 in. long saddle bearing, 100 fpm under 25-lb load.
Glass	15	0.308	0.037	
Glass	35	None	0.289	
Graphite	15	3.51	1.880	
Graphite	35	None	0.981	
Copper	15	3.33	0.184	

Table 9—Hardness at 73 F

Filler	Amount (% by vol)	Shore Durometer* (D Scale)	Rockwell Hardness† (J Scale)
None	..	55	80
Glass	15	60	80
Glass	35	60	74
Graphite	15	56	86
Graphite	35	54	63
Copper	15	65	92

*ASTM D-676-49T †ASTM D-785-51

essentially, all of the expansion in the direction of thickness.

Addition of modifiers increases thermal conductivity of Teflon appreciably, Table 4.

Friction Properties: Coefficient of friction depends on load and velocity and is shown for filled compositions at certain static and dynamic conditions in Table 5. For various metals and polymers, it can be shown to relate to shear strength and hardness. Increasing hardness without appreciably increasing shear strength causes a decrease in the coefficient of friction. This phenomenon may explain why, for certain filled compositions, dynamic friction is lower than that of either the TFE resin or the additive. At static conditions, addition of fillers causes an increase in the coefficient of friction.

Wear and Abrasion Resistance: Wear rate is an important design consideration for many applications. It is necessary, therefore, that test data closely approximate actual conditions of the application. Wear-test data represent results of abrading various filled TFE resins according to the following tests: The Armstrong abrasion test (Procedure B, ASTM D-1242-56) which indicates that addition of modifiers does not always significantly improve abrasion resistance but, in some cases, may even reduce it. Table 6; the Taber abrasion test which causes wear by a tangential sliding movement under a 1000-gram load, Table 7; and a sleeve-bearing test which shows that use of an additive improves wear resistance by as much as 500 times, Table 8.

Another design consideration is wear of the mating surface. In general, most materials have exceedingly light wear when run against Teflon. However, some filled compositions are better than others. In sleeve bearing tests, shaft wear is negligible with both the graphite and copper-filled bearings, while glass-filled compositions cause slight wear.

Hardness: This property is useful as an indication of resistance of a material to plastic deformation and scratches. Durometer and Rockwell hardnesses are both commonly associated with plastics, Table 9.

Dielectric Properties: The excellent dielectric properties of TFE resins are controlled by selection of proper fillers. Data on electrical properties of unmodified Teflon and filled compositions are shown in Table 10.

ACKNOWLEDGEMENT

The author acknowledges with appreciation the co-operation of Mr. Roger Diamond, Mr. Lawrence H. Gillespie, and Dr. John F. Lontz in the preparation of this article.

Table 10—Electrical Properties

Filler	Amount (% by vol)	Sample Thickness (in.)	Dielectric Strength (v per mil)	Dielectric Constant (@ 1000 cps)	Dissipation Factor (@ 1000 cps)	Volume Resistivity (ohm-cm) Initial	Volume Resistivity (ohm-cm) After 24 hr in water	Surface Resistivity (ohms per sq) Initial	Surface Resistivity (ohms per sq) After 24 hr in water
None	..	0.07	400	2.2	0.0002	1.89×10^{19}	1.89×10^{19}	2.6×10^{18}	1.1×10^{18}
Glass	15	0.05	250	2.4	0.0006	5.0×10^{14}	6.7×10^{8}	2.9×10^{13}	4.0×10^{12}
Glass	35	0.05	230	2.8	0.0017	1.25×10^{15}	1.78×10^{8}	2.4×10^{13}	6.1×10^{12}
Graphite	15	0.06	...	..	.....	2.44×10^{6}	.....	1.0×10^{6}	.....
Graphite	35	0.06	...	..	.....	2.44×10^{6}	.....	1.0×10^{6}	.....
Copper	15	0.06	...	..	.....	2.44×10^{6}	.....	1.0×10^{6}	.....

Design of Helical Springs

for minimum "surging" in high-speed operation

By **RAY C. JOHNSON**
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The requirement that a helical spring have a high natural frequency of internal vibration makes it difficult to obtain a satisfactory combination of values for mean spring diameter, wire size, and number of active coils. The mathematical technique derived here provides a method for arriving at a combination of these values which completely specifies the optimum spring.

SATISFACTORY performance of a high-speed mechanism is often dependent upon the behavior of a helical spring. Generally, the spring must have a required force gradient and must also be capable of delivering maximum force for millions of cycles of operation of the mechanism.

It is known that a helical spring has a natural frequency for internal surgings or vibrations. If a spring is excited at its natural frequency, resonance exists, and the internal vibrations could result in improper operation of a mechanism. Internal surgings might cause a follower to bounce from a cam or result in an early spring failure. Because of this inherent resonant possibility, it is desirable to use a helical spring which has the highest possible natural frequency. Resonance will then occur only for the higher order harmonics which are generally of low amplitude.

The purpose of this article is to establish a procedure for designing a long-life helical spring which satisfies force and gradient requirements of the mechanism problem and which has the highest possible natural frequency for internal surgings.

Design Conditions: As shown in Fig. 1, force versus deflection relationship for a helical spring

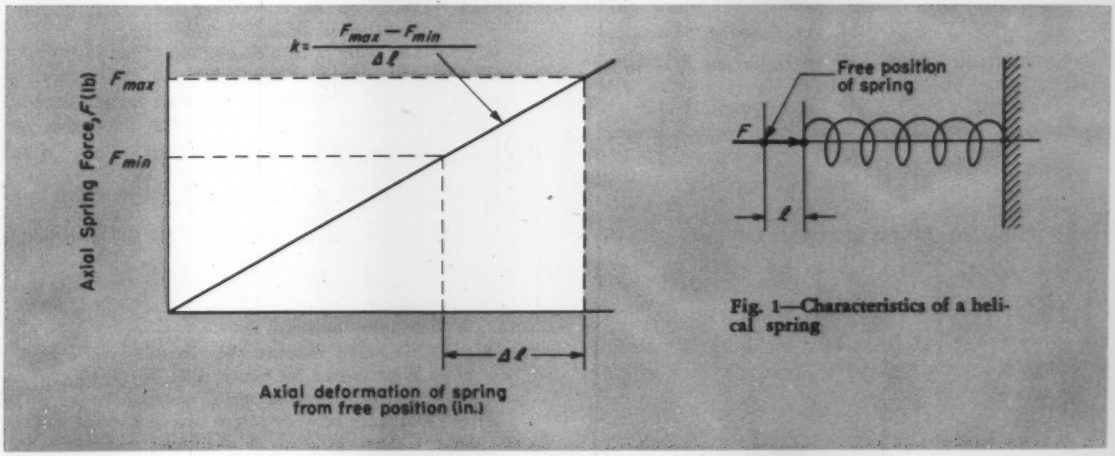


Fig. 1—Characteristics of a helical spring

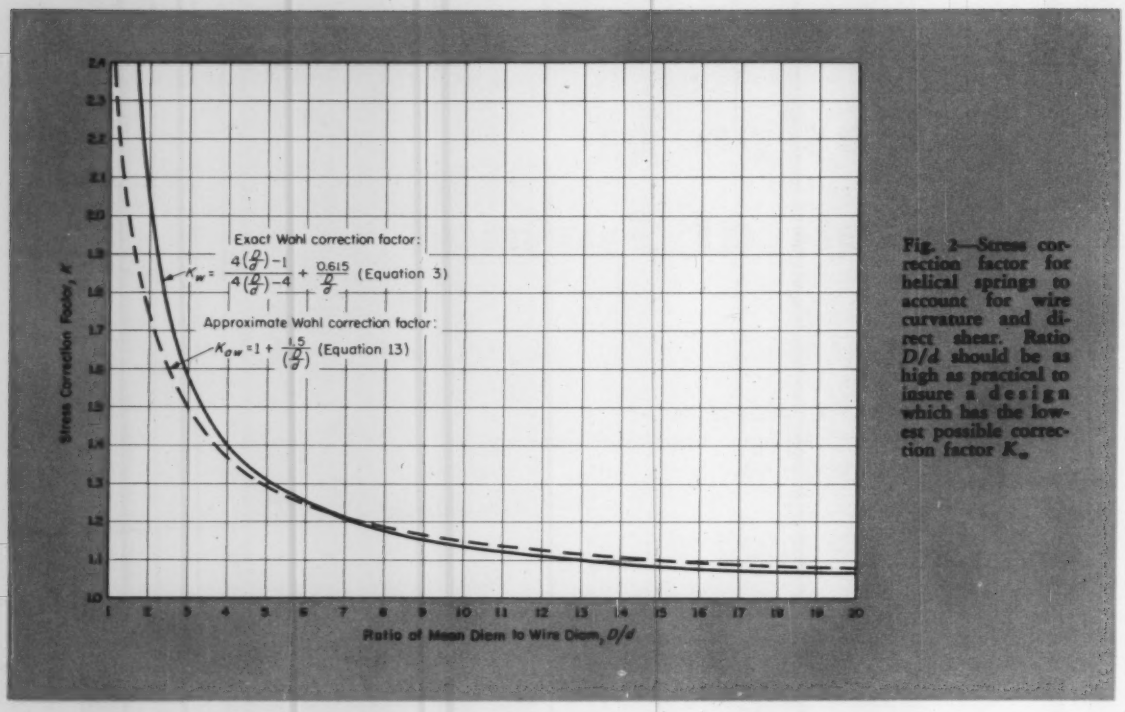

Exact Wahl correction factor:
$K_w = \frac{4(\frac{D}{d})-1}{4(\frac{D}{d})-4} + \frac{0.615}{\frac{D}{d}}$ (Equation 3)
Approximate Wahl correction factor:
$K_{aw} = 1 + \frac{1.5}{(\frac{D}{d})}$ (Equation 13)
Stress Correction Factor, K
Ratio of Mean Diam to Wire Diam, D/d

Fig. 2—Stress correction factor for helical springs to account for wire curvature and direct shear. Ratio D/d should be as high as practical to insure a design which has the lowest possible correction factor K_w

is linear in nature. Slope of the force versus deflection line is known as spring rate, or force gradient, k. Hence spring rate is by definition,

$$k = \frac{F_{max} - F_{min}}{(\Delta l)} \tag{1}$$

Maximum shearing stress in a helical spring is given by

$$S_{max} = \frac{8(F_{max})D}{\pi d^3}(K_w) \tag{2}$$

In Equation 2, K_w is the Wahl correction factor which accounts for effects of wire curvature, direct shear load, and common torsional load. This correction factor is found from

$$K_w = \frac{4\frac{D}{d} - 1}{4\frac{D}{d} - 4} + \frac{0.615}{\frac{D}{d}} \tag{3}$$

Substituting this value of K_w in Equation 2, results in

$$S_{max} = \frac{8(F_{max})D}{\pi d^3}\left[\frac{4\frac{D}{d} - 1}{4\frac{D}{d} - 4} + \frac{0.615}{\frac{D}{d}}\right] \tag{4}$$

The formula for spring gradient k is

$$k = \frac{Gd^4}{8D^3N} \tag{5}$$

The lowest natural frequency for internal surgings of a helical spring clamped between two parallel plates is[1]

$$f_n = \frac{2d}{\pi D^2 N}\sqrt{\frac{Gg}{32w}} \tag{6}$$

For other end conditions, similar formulas exist in terms of d, D, N, G, w, and g.

For most practical problems, required maximum spring force F_{max} and spring rate k are known, and material parameters G, S_{max}, and w are generally known. In addition, for a spring which has already been designed, values of D, d, and N are known. Hence, maximum shearing stress and lowest natural frequency for internal surgings can be calculated from Equations 4 and 6, and Equation 5 used for

Nomenclature

D = Mean diameter of spring, in.
D_{max} = maximum permissible mean diameter, in.
$D_{o\,max}$ = Maximum space available for spring, in.
d = Actual wire diameter selected, in.
d_{max} = Maximum wire diameter, in.
F = Axial load on spring, lb
f_n = Natural frequency for internal surgings, cps
G = Torsional modulus of rigidity for spring material, psi
g = Acceleration constant, 386 in. per sec^2
K_{aw} = Simplified or approximate Wahl correction factor
K_w = Wahl correction factor
k = Spring rate or gradient, lb per in. of deflection
Δl = Change in spring length, in.
M = Spring torque on a spring-loaded oscillating body, lb-in.
N = Number of active coils
S_{max} = Maximum shearing stress in spring wire, psi
W = Wire weight for active coils, lb
w = Specific weight of spring material, lb per cu in.
x = Distance between torque axis and spring axis, in.
$\Delta\theta$ = Change in angle of oscillating arm, rad

[1]References are tabulated at end of article.

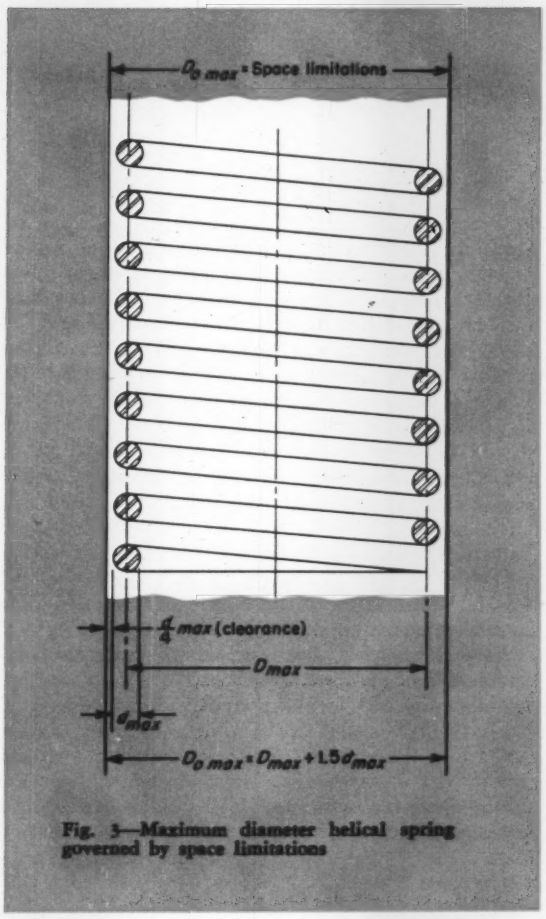


Fig. 3—Maximum diameter helical spring governed by space limitations

checking spring rate k. However, it is often difficult in original design work to arrive at a satisfactory combination of values for D, d, and N.

If the natural frequency for spring surgings, f_n, is neglected, values of D, d, and N can generally be found which satisfy Equations 4 and 5. Many designers use a trial and error solution using the curve of K_w versus D/d, special sliding scales, and nomographs for arriving at a satisfactory combination of D, d, and N. The problem of original design is further complicated by the stipulation of having the natural frequency as high as possible.

The following derivation provides a method for arriving at a combination of D, d, and N so that a desired spring rate exists, so that a maximum shearing stress is not exceeded for a given maximum force, and so that the natural frequency for internal surgings is as high as possible under given space limitations. The method is equally applicable for compression and extension springs.

Design Method Derivation: A formula for the lowest natural frequency for spring surgings is[2]

$$f_n = \frac{1}{2}\sqrt{\frac{gk}{W}} \tag{7}$$

The active-coil spring wire weight W may be approximated with good accuracy by

$$W = w(\pi DN)(\pi/4)d^2 = \frac{\pi^2}{4} wDNd^2 \tag{8}$$

Solving Equation 5 for N and Equation 2 for D, and substituting these values in Equation 8 results in the following equation for active-coil spring wire weight

$$W = \frac{2wG}{k}\left(\frac{F_{max}}{S_{max}}\right)^2 (K_w)^2 \tag{9}$$

Substitution of Equation 9 in Equation 7 results in

$$f_n = \frac{kS_{max}}{2(F_{max})K_w}\sqrt{\frac{g}{2wG}} \tag{10}$$

All terms in Equation 10 are assumed to be known except the Wahl factor, K_w.

From Equation 10, the desirability of having a high natural frequency f_n suggests the following approach: Select a spring wire material which has a high value for $S_{max}/(w\ G)^{1/2}$, and decide on as high a spring rate k and as low a value for F_{max} as possible. In actual design, the spring constant k is often dependent upon F_{max} due to basic requirements of the mechanism for which the spring will be used. Hence, it is more significant to say that a high ratio of k/F_{max} is desirable. Also, the design should result in as low a value for K_w as possible. For a steel spring wire having a torsional rigidity of $G = 11.5 \times 10^6$ psi and a specific weight of $w = 0.283$ lb per cu in., Equation 10 becomes

$$f_n = \frac{3.85k(S_{max})}{(F_{max})K_w}(10^{-3}) \tag{11}$$

Often, a higher value for S_{max} can be used if the springs are shotpeened.

For a design to have as low a value for K_w as possible, the ratio D/d, from Equation 3, should be as high as practical, Fig. 2. Hence, the largest possible mean diameter D should be used. This condition is also desirable from the standpoint of preventing buckling of compression springs.

Maximum mean diameter D_{max} is governed by space limitations, practicality, and limitations on the minimum number of active coils which can be specified. For example, assume that the maximum lateral space available for a helical spring, Fig. 3, be denoted by $D_{o\ max}$. To allow a small amount of clearance on each side of the spring, assume that the maximum space available is $D_{max} + 1.5\ d_{max}$. Hence,

$$D_{o\ max} = D_{max} + 1.5d_{max} \tag{12}$$

where D_{max} and d_{max} are maximum permissible values of D and d as governed by space limits $D_{o\ max}$.

Using Equation 3, a curve of K_w versus d/D was drawn instead of the conventional curve of K_w versus D/d. The shape of such a curve suggests this simplified approximation for K_w

$$K_{aw} = 1 + \frac{1.5}{\frac{D}{d}} \qquad (13)$$

where K_{aw} stands for approximate Wahl correction factor. This approximation is acceptably accurate for all values of D/d greater than 4.

Equation 13 is plotted in Fig. 2 alongside Equation 3, and a curve of the per cent error in using the approximation is shown in Fig. 4. For all values of D/d greater than 5, the error is less than 1 per cent. This degree of accuracy is generally more than required, and the error approaches zero as D/d approaches infinity.

As previously explained a large value for D/d is desirable to have the natural frequency f_n as high as possible. Hence, Equation 13 is generally a sufficiently accurate one for the Wahl correction factor. Also, it has other advantages over Equation 3 in that it is easy to use and it greatly simplifies the calculation of wire diameter d.

Assume that D/d is greater than 4, which is generally the case in good design. Equation 4 for stress then becomes

$$S_{max} = \frac{8(F_{max})D}{\pi d^3}\left[1 + \frac{1.5}{\frac{D}{d}}\right]$$

or

$$S_{max} = \frac{8(F_{max})}{\pi d^3}[D + 1.5d] \qquad (14)$$

Dividing numerator and denominator of Equation 14 by d results in

$$S_{max} = \frac{8F_{max}}{\pi d^2}\left[1.5 + \frac{D}{d}\right] \qquad (15)$$

From this equation, it is apparent that a large value for D/d implies a large value for d and hence of D. This can be seen if F_{max} and S_{max} are both given values, and Equation 15 is solved for d^2.

Substituting $D_{o\,max}$ for its value in Equation 12 into Equation 14 gives

$$S_{max} = \frac{8(F_{max})}{\pi(d_{max})^3}[D_{o\,max}]$$

for maximum permissible diameter spring.

Therefore,

$$d_{max} = 1.366\sqrt[3]{\frac{(F_{max})(D_{o\,max})}{(S_{max})}} \qquad (16)$$

Since F_{max} is known, the space limitation $D_{o\,max}$ and the allowable material shearing stress S_{max} are also known, and the largest wire diameter d_{max} can be calculated directly from Equation 16. It should be emphasized that the Wahl correction factor is automatically taken care of in Equation 16. When a value for d_{max} is calculated from Equation 16, the closest standard wire size below this value should be selected and its diameter denoted by d.

Using Equation 14, it is now possible to calculate actual mean diameter D. Rearranging Equation 14,

$$D = 0.3927\frac{(S_{max})d^3}{(F_{max})} - 1.5d \qquad (17)$$

Again, Equation 17 includes the effects of Wahl's correction factor.

As a final step, the number of coils may be calculated from Equation 5, which may be rewritten

$$N = \frac{Gd^4}{8D^3k} \qquad (18)$$

For steel spring wire with $G = 11.5 \times 10^6$ psi, Equation 18 becomes

$$N = (1.438 \times 10^6)\frac{d^4}{D^3k} \qquad (19)$$

In many cases, the nearest whole number of coils will be accurate enough.

The foregoing method permits calculating values for d, D, and N which completely specify the required spring. A spring so designed will have the highest possible natural frequency for internal surgings, the required stress value for a given force,

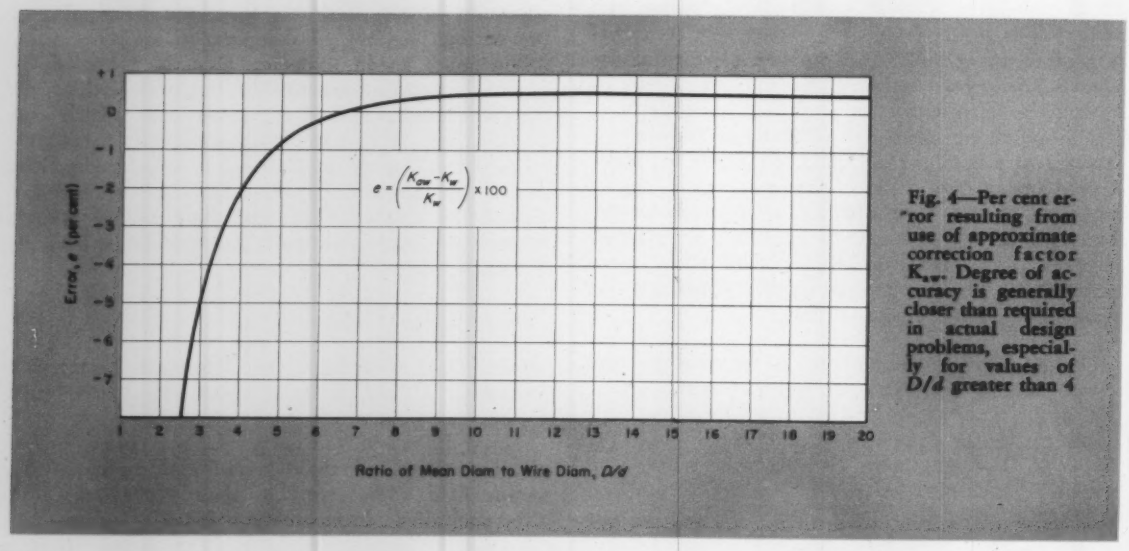


Fig. 4—Per cent error resulting from use of approximate correction factor K_{aw}. Degree of accuracy is generally closer than required in actual design problems, especially for values of D/d greater than 4

and the proper spring rate.

Summary of Design Procedure: Given F_{max}, k, $D_{o\,max}$, and material parameters S_{max}, G, and w:

1. If the choice exists, select a material which has the largest value of $S_{max}/(w\,G)^{1/2}$.
2. From Equation 16, calculate d_{max} and choose actual d as the next lowest standard wire size available.
3. From Equation 17, calculate mean diameter D.
4. From Equation 18 or 19, calculate number of active coils N.
5. Values for d, D, and N completely specify the optimum spring.
6. Equation 6, 10, or 11 may now be used to calculate f_n. For the given values of k, S_{max}, and F_{max}, the value so calculated is the highest possible.
7. Equations 2, 3, 4, and 5 may be used to check these values.

The following example illustrates this procedure.

Problem:

Design a helical spring having a spring rate k = 10 lb per in. and which is capable of delivering a maximum spring force F_{max} = 20 lb. The natural frequency for internal surgings for the spring should be as high as possible, and lateral space limitations dictate $D_{o\,max}$ = 1 in. The spring should be as short as possible, and a high grade of spring steel wire must be used. Maximum allowable shearing stress for the wire is 68,000 psi, Wahl corrected.

Calculate the optimum combination for D, d, and N, which will completely specify the desired spring, and determine the natural frequency for internal surgings of the springs

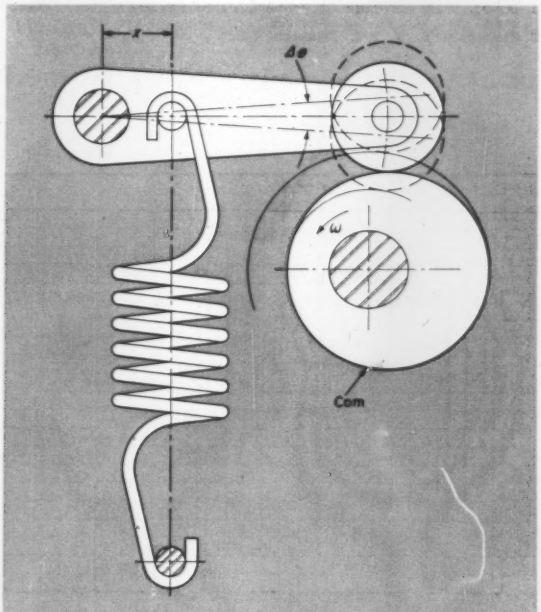


Fig. 5—Spring-loaded oscillating follower cam. Natural frequency of the helical spring is highest when distance x is as small as possible

Solution:

From Equation 16,

$$d_{max} = 1.366 \sqrt[3]{\frac{(20)(1)}{(68{,}000)}} = 0.091 \text{ in.}$$

Assume that the next smallest standard wire size available is 0.090 in. Using this value for d, mean diameter is, from Equation 17,

$$D = 0.3927 \frac{(68{,}000)(.090)^3}{(20)} - (1.5)(0.090) = 0.839 \text{ in.}$$

Therefore, D/d = 0.839/0.090 = 9.33, and the approximation used in the derivation should be accurate, Fig. 4. Outside diameter of the spring is 0.839 + 0.090 = 0.929 in. This allows a small amount of lateral clearance from the maximum space limitations. Actual clearance = (1.000 − 0.929)/2 = 0.0355 in.

From Equation 19, number of coils is

$$N = (1.438)(10^6)\frac{(0.090)^4}{(0.839)^3(10)} = 16.0$$

and the spring is specified according to calculated values of d, D, and N.

From Equation 11, natural frequency is

$$f_n = \frac{3.85(10)(68{,}000)(10^{-3})}{(20)K_w} = \frac{131}{K_w}$$

but using Equation 13, since D/d = 9.33,

$$K_w = K_{aw} = 1 + \frac{1.5}{933} = 1.16$$

Hence, f_n = 131/1.16 = 113 cps. As a check, Equation 6 also gives f_n = 113 cps.

To increase the natural frequency for internal surgings it would be necessary to increase the ratio of k/F_{max} or increase the allowable S_{max}.

Spring-Loaded Oscillating Members: A helical spring is often used on oscillating parts such as a cam mechanism, Fig. 5. Again, natural frequency for internal surgings should be as high as possible for optimum operation. To find the highest natural frequency, assume that the motion of the oscillating body, the inertias, frictional forces, and all external forces to the oscillating body are known. Also, assume that maximum and minimum spring torque and angle of swing, $\Delta\theta$, Fig. 5, are known. Using the principle of moments

$$F_{max} = \frac{M_{max}}{x} \tag{20}$$

From Equation 1, the required spring constant is

$$k = \frac{F_{max} - F_{min}}{\Delta l} = \frac{\frac{M_{max}}{x} - \frac{M_{min}}{x}}{x(\Delta\theta)}$$

Therefore,

$$k = \frac{(M_{max} - M_{min})}{x^2(\Delta\theta)} \tag{21}$$

Substituting Equations 20 and 21 in Equation 10

gives

$$f_n = \frac{(M_{max} - M_{min})(S_{max})}{2(\Delta\theta)(M_{max})(K_w)x}\sqrt{\frac{g}{2wG}} \qquad (22)$$

Since the natural frequency f_n should be as high as possible, an approach can be followed similar to the one suggested by Equation 10 previously. Again, a reasonably large value for D/d is desirable. More important, however, is the x term in the denominator of Equation 22. Natural frequency will be highest if x, Fig. 5, is chosen as small as possible. Choosing x as small as possible is also desirable in that the inertia effect of the helical spring on the oscillating arm is thus minimized. This can be verified by substituting Equations 20 and 21 in Equation 9

$$W = \frac{2wG(M_{max})^2(\Delta\theta)}{(S_{max})^2(M_{max} - M_{min})}(K_w)^2 \qquad (23)$$

Equation 23 shows that the weight of the optimum helical spring is independent of the value of x. However, inertia effects of the spring on the arm are proportional to $W x^2$.

Summary of Design Procedure: Given M_{max}, M_{min}, $\Delta\theta$, $D_{o\ max}$, and material parameters S_{max}, G, and w:

1. If the choice exists, select a material which has the largest value for $S_{max}/(w\ G)^{1/2}$.
2. Choose torque arm x, Fig. 5, as small as practical.
3. Calculate F_{max} from Equation 20.
4. Calculate k from Equation 21.
5. From Equation 16, calculate d_{max} and choose actual d as the next lowest standard wire size available.
6. From Equation 17, calculate mean diameter D.
7. From Equation 18 or 19, calculate number of active turns N.
8. Values for d, D, and N completely specify the optimum spring.
9. Equation 6, 10, or 11 may now be used to calculate f_n.
10. Equations 2, 3, and 5 can be used to check these values.

Length Limitations: If it is desirable to have a helical spring be as short as possible because of space limitations, assume that maximum spring force, desired spring rate, and material parameters are known quantities. The solid active coil length for a helical spring is equal to

$$L = Nd \qquad (24)$$

Hence, Equation 8 solved for Nd becomes

$$L = Nd = \frac{4W}{\pi^2 D d w}$$

However, if the value for W from Equation 9 is used, then

$$L = \frac{8G(F_{max})^2(K_w)^2}{\pi^2 k(S_{max})^2(Dd)} \qquad (25)$$

From Equation 25 it can be seen that a minimum length spring is obtained if K_w is low, and that D/d, again, should be as large as possible. As before, F_{max} should be as small as possible, and k and S_{max} should be as large as possible. If k is dependent upon F_{max}, it is more significant to look at the ratio of F_{max}^2/k. Hence, for minimum length, the ratio F_{max}^2/k should be as small as possible or the ratio k/F_{max}^2 as high as possible. In other words, the space limitation desirability for having a short length is compatible with the desirability for having a high resonant frequency for surgings. Having D as large as possible and L as short as possible is equally desirable from the standpoint of preventing buckling of compression springs.

REFERENCES

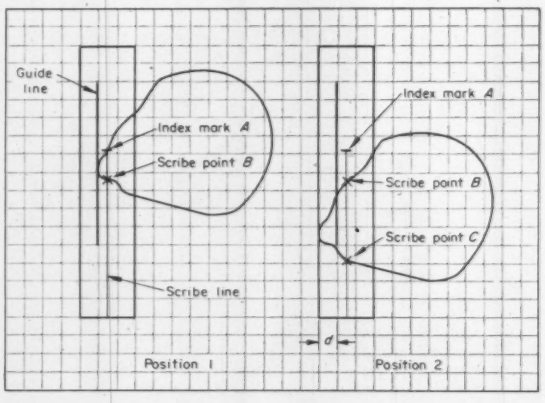
1. A. M. Wahl—*Mechanical Springs*, Penton Publishing Co., Cleveland, 1944, p. 232, Equation 236.
2. Reference 1, p. 231, Equation 235.

Tips and Techniques

Measuring Irregular Areas

Areas under curves and within irregular figures can be measured without a planimeter by a method less tedious than counting squares. Two parallel lines are scribed on a piece of celluloid or on a transparent drafting triangle. The distance between the lines should be one-half the distance between the grid lines on the graph paper on which the curve is plotted. Make a short index mark at the beginning of the right-hand or scribe line, and fill the index mark and left-hand or guide line with ink to aid visibility.

The guide line is aligned over the grid line nearest the left side of the curve, with the index mark cutting the curve. A scriber is drawn down the scribe line until the baseline of the curve or the bottom of the figure is reached. Keeping the scriber at this point on the scribe line, the instrument is moved until the guide line is aligned over

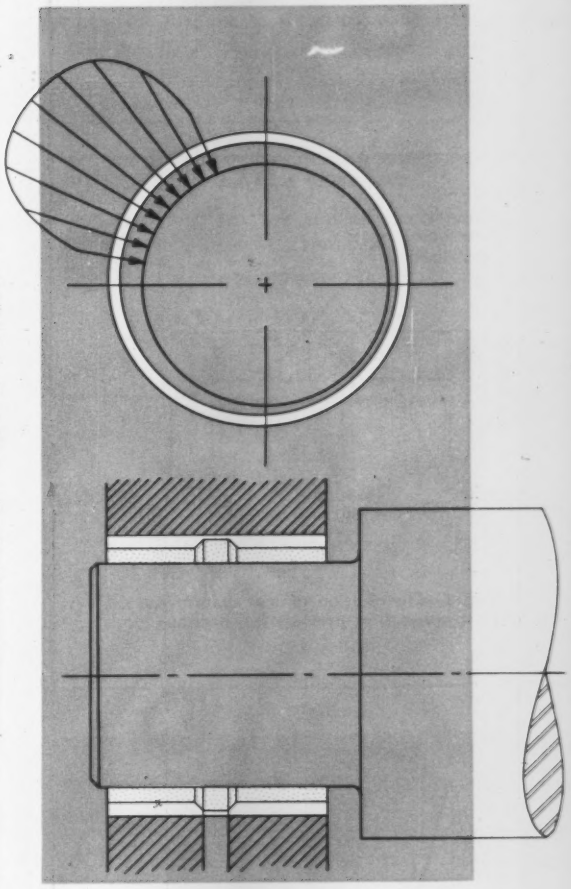


the next grid line and the scriber touches the curve. The process is then repeated for successive grid lines. The area is equal to the distance traveled by the scriber, AC, times the distance between grid lines, d.—LEWIS F. GARBER, *Pasadena, Calif.*

Pressure-Fed Bearings

. . . a designer's guide

At best, designing plain bearings is a process of compromise. But, it need not be a complicated process. Here is bearing design made easy . . . a practical engineering approach to balancing the many variables involved.



By DONALD J. MYATT
Associate Professor of Engineering
Antioch College
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PLAIN journal bearings may be divided into four types, depending upon the application: 1. Oscillating or squeeze-film bearings. 2. Ring-fed rotating bearings with thick-film lubrication. 3. Ring-fed rotating bearings with thin-film lubrication. 4. Pressure-fed bearings. In each case, the bearing design is governed by different principles relating the interaction of the load, journal, bearing, and lubricant.

For a pressure-fed bearing of the type commonly used as the main and crankpin bearings in an internal-combustion engine, it is assumed[1] that:

1. The bearing is capable of withstanding a force acting in any direction normal to its axis.
2. Length-diameter ratio may be small, for example, 0.5 or even less.
3. In some cases, the bearing may operate with a high degree of eccentricity.
4. Rate of heat generation is sufficiently high for the oil to be considered as acting as a coolant as well as a lubricant.
5. Oil is supplied under pressure in such a fashion that the entire clearance space may be considered as filled with oil at all times. Since the oil is normally supplied through grooves or holes near the longitudinal centerline, its path of flow to the point of escape is generally axial.

[1]References are tabulated at end of article.

Nomenclature

c = Radial clearance, in.
d = Journal diameter, in.
f = Coefficient of friction
H_1 = Heat generation rate, Btu/min
H_3 = Heat removal rate, Btu/min
h_0 = Minimum oil-film thickness, in.
L = Equivalent bearing length = 0.5 l for central-grooved bearings, in.
l = Bearing length, in.
N = Speed, rpm
P = Average bearing load = $W/2rl$, psi
p = Oil supply pressure, psi
Q = Rate of oil flow, gpm
r = Journal radius, in.
S = Bearing characteristic number = $(\mu N/P)(r/c)^2$, sec/min
T = Initial oil temperature, F
t = Average oil temperature = $T + (\Delta t/2)$, deg F
W = Load, lb
Δt = Temperature rise, deg F
μ = Viscosity of oil, reyns

Axial and longitudinal sections through a journal

and pressure-fed bearing are shown at the beginning of this article. The journal rotates in the bearing. Dennison[2] has suggested several criteria for safe design of a bearing of this type. Among them are to provide sufficient lubricant so that the mean rise in oil temperature does not exceed a limiting value and to maintain a minimum oil-film thickness that prevents metal-to-metal contact between journal and bearing.

Oil Flow: Often, pressure-fed bearings are located in unexposed, high-temperature regions within a machine. In such cases, it is realistic to assume that all heat generated within the bearing must be carried away by oil fed to the bearing. The heat generated by a shaft rotating in its bearing is given by

$$H_1 = \frac{fWrN}{1490} \qquad (1)$$

For design purposes and for estimating the equilibrium temperature of the bearing, the journal may be assumed to be concentric with the bearing. In this case, Petroff's formula for coefficient of fluid friction can be substituted into Equation 1 to give:

$$H_1 = \frac{\mu N^2 r^3 l}{2250c} \qquad (2)$$

The amount of heat, H_3, which the oil removes with a given temperature rise, Δt, as it flows through the bearing is

$$H_3 = 3\,Q(\Delta t)$$

The rate of oil flowing through a circumferentially-grooved bearing in which the journal is assumed to be concentric with the bearing has been determined by Slaymaker[3] and others.[4] Their formula for Q yields, when substituted in H_3 and equating H_3 to H_1:

$$\Delta t = \left(\frac{272}{10^6}\right)\left(\frac{Nrl}{c^2}\right)^2\left(\frac{\mu^2}{p}\right) \qquad (3)$$

where Δt is the average temperature rise of the oil from the time it enters the bearing at the central oil-supply groove until it escapes from the sides of the bearing, Fig. 1.

Tests reported by Fuller[5] show that when the oil is fed through a single hole, oil flow to the bearing is only one-fourth that of a circumferentially grooved bearing. Consequently, the temperature rise in a single-hole, pressure-fed bearing is four times that of a grooved bearing.

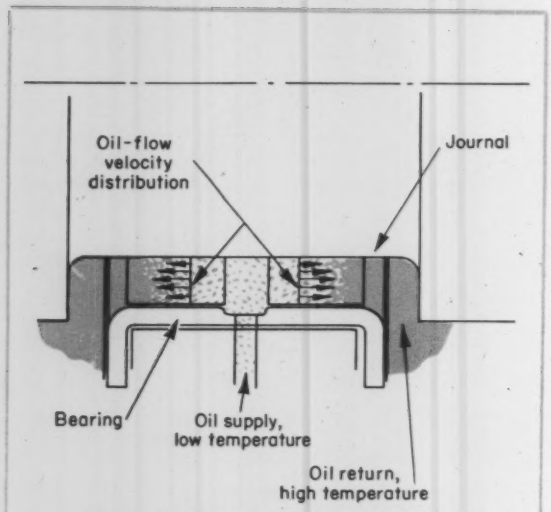


Fig. 1—Distribution of temperature and oil flow through a pressure-fed bearing

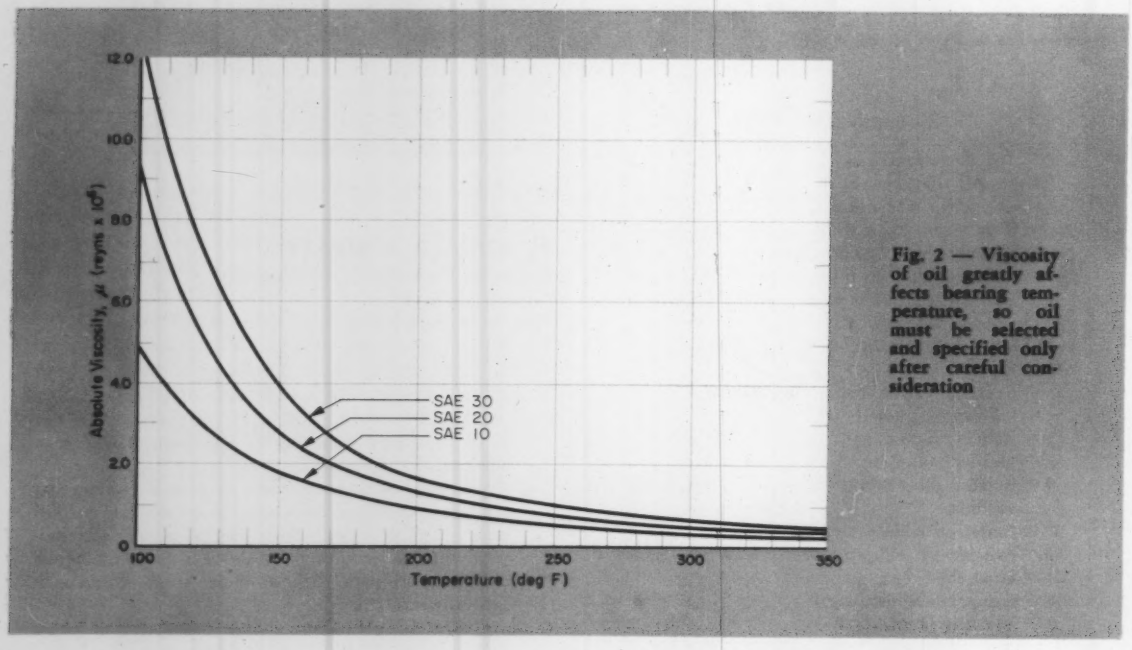


Fig. 2 — Viscosity of oil greatly affects bearing temperature, so oil must be selected and specified only after careful consideration

Equation 3 provides a sound basis for the design of a pressure-fed bearing. Usually the bearing radius, journal speed, and oil supply pressure are known or can readily be assumed. The problem then becomes one of finding bearing length, clearance, and oil viscosity so the temperature rise does not exceed some limiting value. Fig. 2.

Temperature Rise: Bearings operating in the usual pressure-fed bearing environments operate at high temperatures—sometimes approaching the maximum temperature recommended for the oil. It is important, therefore, that temperature rise of oil passing through the bearing be limited to a small value. Fuller[6] indicates that reasonable temperature rises range from 10 to 20 F and permissible temperature rises may range from 5 to 50 F.

Design Limits: Three aspects of bearing design must be watched carefully—bearing size, bearing-clearance modulus, and oil viscosity.

BEARING SIZE: Pressure-fed bearings are often ap-

Example 1—Finding oil temperature rise and running temperature

Assuming a bearing with central groove; bearing is 2 in. wide and 4 in. diam. Assume following data:

Oil: SAE 10

Radial clearance, c: 0.0120 in.

Journal speed, N: 3600 rpm

Avg bearing load, P: 150 psi

Oil supply temperature, T: 120 F

Oil supply pressure, p: 10 psi

Equation 3 provides rise in temperature

$$\Delta t = \left(\frac{272}{10^6}\right)\left(\frac{3600 \times 2 \times 2}{0.0120^2}\right)^2\left(\frac{\mu^2}{10}\right)$$

$$\Delta t = (2.72 \times 10^{11})\mu^2$$

For SAE 10 oil: Assume t = 121 F; use viscosity-temperature chart.

$$\mu = 2.8 \times 10^{-6} \text{ reyn}$$

$$\Delta t = (2.72 \times 10^{11})(2.8 \times 10^{-6})^2 = 2.12 \text{ F}$$

Bearing operating temperature: Solved value for t checks assumption.

$$t = T + \frac{\Delta t}{2}$$

$$t = 120 + \frac{2.12}{2} = 121.1 \text{ F}$$

Example 2—Finding minimum oil-film thickness

Assume same bearing and oil as in Example 1

Bearing characteristic number,

$$S = (r/c)^2(\mu N/P)$$

$$S = 6.6 \times 10^5 \mu$$

For SAE 10 oil: Use Fig. 3; c = 0.012 in.

$$S = (6.6 \times 10^5)(2.8 \times 10^{-6}) = 1.85$$

$$L/d = (1/2)(l/d) = 0.25$$

$$h_0/c = 0.07$$

$$h_0 = (0.07)(0.012) = 0.00084 \text{ in.}$$

When the radial bearing clearance, c, is given:

For SAE 10 oil:

$$c = 0.010 \text{ in.}$$

$$S = 9.6 \times 10^5 \mu$$

$$S = 2.78$$

$$h_0 = 0.0009 \text{ in.}$$

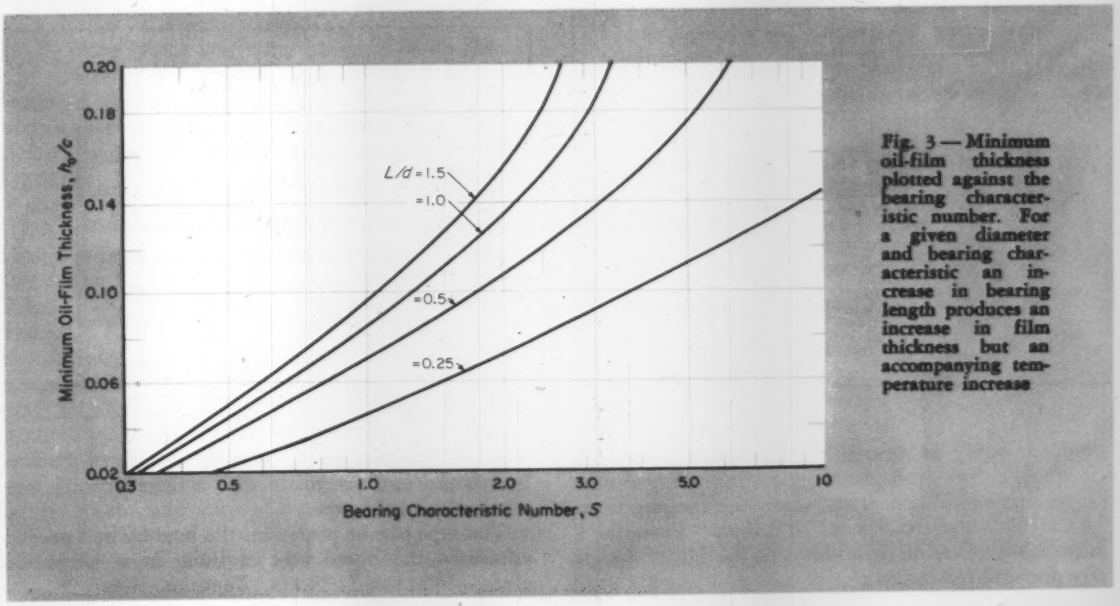


Fig. 3 — Minimum oil-film thickness plotted against the bearing characteristic number. For a given diameter and bearing characteristic an increase in bearing length produces an increase in film thickness but an accompanying temperature increase

plied in machines where space is a minimum. Consequently, the smallest values of l/d ratio are used with this type bearing. Present practice indicates a range of l/d ratio equal to 0.5 to 2.

BEARING CLEARANCE MODULUS: The clearance between journal and bearing is usually given as a ratio of radial-clearance-to-journal radius, c/r, called the clearance modulus. Current design practice indicates a range of c/r ratio of 0.0004 to 0.004.

OIL VISCOSITY: A range of satisfactory oil viscosity would probably be covered by oils ranging from SAE 10 to 30. For the usual operating temperature range, this would encompass viscosities ranging from 0.5×10^{-6} reyn to 5.0×10^{-6} reyn. Example 1 illustrates the use of Equation 3 in the initial design of a pressure-fed bearing.

Pinning Down the Variables

Calculations show that a bearing which is running too hot may be made to run cooler by changing to a lighter grade of oil or by increasing the bearing clearance. The minimum oil-film thickness can be increased by going to a heavier oil. Data show that there is an optimum clearance which produces a maximum value of minimum oil-film thickness. Specifying a clearance less than this optimum value produces a smaller minimum film thickness; specifying a clearance greater than optimum also produces a smaller film thickness.

Temperature Rise and Film Thickness

(Bearing 4 in. diam, 2 in. long; bearing pressure 150 psi)

Oil	Bearing Clearance	0.012 in.	0.010 in.	0.008 in.
SAE 10	t, deg	2	5	10
	h_0, in.	0.00084	0.00090	0.00083
SAE 20	t	7	13	26
	h_0	0.00094	0.00110	0.00098
SAE 30	t	12	21	35
	h_0	0.00127	0.00120	0.00107

Results of calculations for a bearing with 0.010 in. clearance indicate that lengthening the bearing increases the running temperature. Also, the minimum oil-film thickness is increased. Comparing a bearing under 150 psi loading with a similar one under 1000 psi loading reveals that very little increase in running temperature need be expected. The minimum oil-film thickness is decreased significantly under the increased load, however.

Effect of Bearing Length and Pressure

(Same bearing, clearance 0.010 in.)

Oil	Pressure 150 psi Width 2 in.	150 psi 4 in.	1000 psi 4 in.
SAE 10	t, deg 5	15	15
	h_0, in. 0.00090	0.00120	0.00024
SAE 20	t 13	33	33
	h_0 0.00110	0.00144	0.00040
SAE 30	t 21	46	46
	h_0 0.00120	0.00160	0.00048

Oil-Film Thickness: Experimental work reported by Dennison[7] indicates that pressure distribution of lubricant in a pressure-fed bearing differs from that in the classical 360-degree bearing usually discussed under thick-film lubrication; actual behavior of a pressure-fed bearing is closer to that of 120-degree offset bearing. Dennison analyzed the pressure-fed bearing for this condition and accounted for the end-leakage effects. Fig. 3 is a plot of his data in terms of minimum-oil-film-thickness ratio h_0/c and bearing characteristic number S. Dennison recommends a minimum value of h_0/c equal to 0.0001. A design value of h_0/c may be established also by taking into account the bearing and journal surface finish.

Example 2 illustrates use of data in Fig. 3 in checking the bearing design established by Equation 3. Tables at the left summarize results obtained in Examples 1 and 2 and discuss some common characteristics of plain journal bearing.

REFERENCES

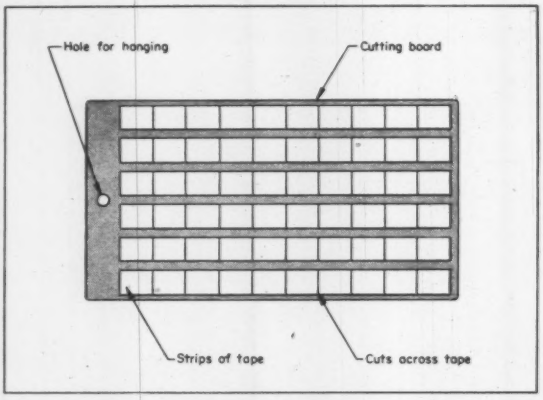
1. E. S. Dennison—"Film Lubrication Theory and Engine-Bearing Design," *Transactions ASME*, Vol. 58, 1936, p. 25.
2. Reference 1, p. 35.
3. R. R. Slaymaker—*Bearing Lubrication Analysis*, John Wiley and Sons Inc., New York, 1955, pp. 44-45.
4. J. E. Shigley—*Machine Design*, McGraw-Hill Book Co. Inc., New York, 1956, pp. 295-296.
5. D. D. Fuller—*Theory and Practice of Lubrication for Engineers*, John Wiley and Sons Inc., New York, 1956, p. 255.
6. Reference 5, p. 252.
7. Reference 1, p. 25.

Tips and Techniques

Masking Tape Cutting Board

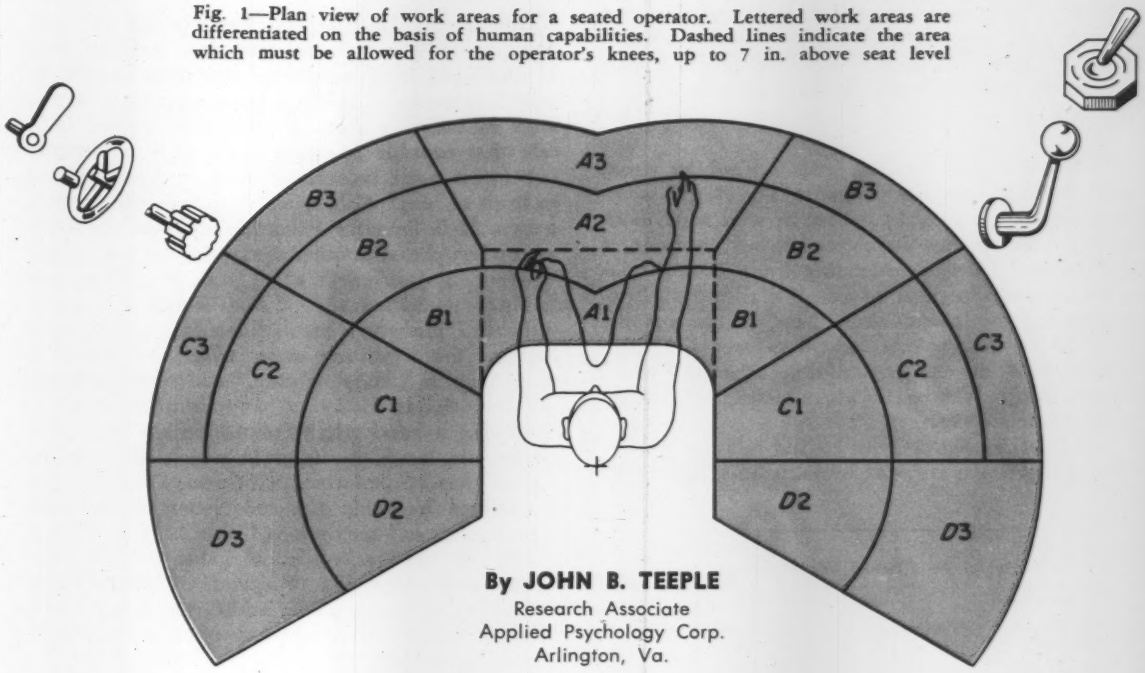
For best results in fastening drawings to the board, the masking tape should be cut clean and straight.

Illustrated is a handy method which produces a large supply of trimmed, ready-to-use sections of tape. Strips of tape are placed on a hard-surfaced board, and cuts are made with a razor or knife perpendicular to the tape.



The tape can be peeled off the board when needed; otherwise the board can be hung in a convenient place.—WALTER L. STEIN, *Kenosha, Wis.*

Fig. 1—Plan view of work areas for a seated operator. Lettered work areas are differentiated on the basis of human capabilities. Dashed lines indicate the area which must be allowed for the operator's knees, up to 7 in. above seat level



By JOHN B. TEEPLE
Research Associate
Applied Psychology Corp.
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From research in human engineering comes a designer's guide for

Locating Hand-Operated Controls

OPERATORS of today's complex equipment often face a confusing array of levers, handwheels, knobs, and toggle switches. It is the designer's responsibility to determine the locations of these hand-operated controls in accordance with data on operator variables. Different work areas dictate different types of controls, as defined in terms of characteristics of operator performance.

There is considerable literature on this subject, which defines work areas for standing and seated operators,[1, 2] for specific tasks,[3, 4] for different types of seat back angles,[5] and for various conditions of clothing.[4, 6] Total work space of the hand has been divided into areas in terms of ease of reach,[1, 6] and maximum arm reach of small and large operators.[3, 6, 7] Maximum boundary of these areas is the maximum distance at which a control may be placed.

These studies define the total area which can be reached, but provide little information for determining the optimum location of the controls.

A recent review of the work space problem as applied to seven aircraft crew stations,[4] delineated different sections of the total work area in terms of operator performance. The work area on a horizontal work surface, 12 in. above the seat reference point, was divided into ten subareas by combining

Table 1—Work Areas and Control Uses

Code Letter	Operational Description	Appropriate Work Areas (From Fig. 1)
	Condition of Use:	
A	Frequent	*A1, A2, B1, C1, B2, C2*
B	Infrequent	*A3, B3, C3, D2, D3*
C	Acute vision	*A1, A2, A3, B1, B2, B3*
D	Not acute vision	*C1, C2, C3, D2, D3*
E	Blind conditions	*A2, B2*
F	While sighting	*A2, A3*
G	Requiring two hands	*A1, A2, A3*
H	Continuous	*A1, A2, B1*
I	Under g forces	*A1, B1*
	Control Characteristics:	
J	Finger (pushbutton, toggle)*	*A3, B3, C3, D2, D3*
K	Finger, thumb (knob)*	*A2, B2, C2, D2*
L	Full hand (handle)*	*A2, B2, C2*
M	Fine adjustment	*A1, A2, B1, B2*
N	Discrete positions*	*A3, B3, C1, C2, C3, D2, D3*
O	Over 25 lb force	*A2, B2, C2, D3*

*Areas given are maximum distance from operator. Nearer areas are also appropriate.

[1]References are tabulated at end of article.

existing data on arm reach[6] and binocular vision.[2] The combined data indicate not only where a man can reach, but how well he can see where he is reaching.

Vision and Arm Reach: Areas defined by visual and reach criteria are shown in Fig. 1. All areas designated by the letter *A* can be seen when both eyes are focused on an object directly in front of the operator. Area *B*, extending from 30 to 60 degrees from midline, can be seen if slight head or eye movements are made. Gross head movements are required to view objects located in area *C*, which extends to 90 degrees from midline. Binocular vision cannot occur in area *D* when restrictive clothing or headgear are worn.

Numbers in Fig. 1 refer to the relative amount of arm movement required to reach into these areas.

Table 2—Coded Work Areas

Work Area	Appropriate Operations (From Table 1)
A1	A, C, G, H, I, M
A2	A, C, E, F, G, H, K, L, M, O
A3	B, C, F, G, J, N
B1	A, C, H, I, M
B2	A, C, E, K, L, M, O
B3	B, C, J, N
C1	A, D, N
C2	A, D, K, L, N, O
C3	B, D, J, N
D2	B, D, J, K, N
D3	B, D, J, N, O

The number 1 indicates areas which can be reached without outward movement of the upper arm. Number 2 refers to areas which may be reached by movements of upper and lower arm. Horizontal extension of the whole arm and shoulder is required to reach objects in number-3 areas.

These visual and arm-reach data may be used as descriptions of man's behavior in operating controls. For example, it can be assumed that only infrequently used controls should be placed at maximum arm reach. Controls used while sighting or adjusting readings on displays placed directly in front of the man should be visible without removing the eyes from an object in front of the operator. Area *A3* may then be regarded as suitable for use while sighting, and for infrequently used controls. If there were only a few controls involved, all of them should be placed in area *A1* or *A2*, the most efficient areas as defined by these criteria. However, with large numbers of controls, which are used in different ways and under different conditions, the problem is not so simple.

A toggle switch used once an hour to turn equipment "On" or "Off" can be placed in area *D* without severely restricting the operator's efficiency. However, if a frequently used two-handed control is located in area *B2*, severe fatigue and inefficiency will result. Therefore, to locate controls in appropriate work areas, it must be known what operations can be easily accomplished in each area.

Operational Descriptions: Descriptions of these areas in terms of control-operating behavior may be developed from knowledge of human factors required to perform different types of control operations in different areas. For example, studies indicate that controls operated under high accelerative (*g*) forces must be located near the operator and in front of him.[8] Also, most controls requiring more than a 25-lb force for activation are most efficiently used when placed in other sections of the work area.[9] Operational descriptions of all work areas illustrated in Fig. 1 can be derived.

Table 1 presents a list of these descriptions, some defining the conditions under which the control is used, such as "while sighting," and others defining physical characteristics of controls themselves, as "requiring a hand grip." Following each descriptive phrase are listed the areas in which the task described may be performed with ease. Each area can be defined by using the code letters representing these operational descriptions, Table 2.

Items in the first column of Table 1 do not constitute a complete list of operational descriptions. Others would have to be added for specific jobs. However, these will serve to demonstrate the technique of matching.

Matching: Data in Tables 1 and 2 may also be applied to controls. If the physical characteristics of the controls (force required, type of grip, etc.) and the conditions under which they will be used are known, codes may be assigned to each control. The power control in military aircraft, for example, may be described and coded as frequently used (A), used while sighting (F), used under high accelerative forces (I), requiring full-hand grip (L), and needing fine adjustments (M).

Once code letters have been assigned to controls and work areas, these may be matched on the basis of common code elements. In the case of the power control, for example, Table 2 indicates that Area *A1*, with a code of ACEFGHIKLMO, contains all the letters which appear in the code for the power control. The power control should, therefore, be placed in Area *A1* to satisfy human factor requirements. Optimum location of other controls may be determined in a similar manner.

REFERENCES

1. R. M. Barnes—*Motion and Time Study*, John Wiley and Sons, Inc., New York, 1940.
2. B. G. King—"Functional Cockpit Design," *Aero. Engng. Rev.*, Vol. 11 (6), 1952, pp. 32-40.
3. B. G. King, D. J. Morrow, and E. R. Vollmer—*Cockpit Studies: The Boundaries of the Maximum Area for the Operation of Manual Controls*, NMRI Project No. X-651, Rep. No. 3, July 1947.
4. J. B. Teeple, H. J. Bond, and R. B. Sleight—*Human Engineering Appraisal of Aircraft Crew Stations: Final Report*, Contract AF 33(616)2843. USAF, WADC, Dayton, Ohio, September, 1955.
5. J. H. Ely, R. M. Thomson, and J. Orlansky—*Layouts of Workplaces: Chap. V of the Joint Services Human Engineering Guide to Equipment Design*, USAF, WADC TR 56-171, September, 1956.
6. I. Emmanuel and C. A. Dempsey—*Spatial Arrangements for Aircrew Stations: I. Arm Reach as Affected by the T-1 Partial-Pressure Suit*, USAF, WADC Tech. Rep. 54-247, 1954. (In preparation)
7. K. O. W. Sandbert and H. L. Lipschulta—*Maximum Limits of Working Areas on Vertical Surfaces*, The Johns Hopkins Univ., Md. Rep. No. 166-I-8, 1947.
8. A. A. Canfield, A. L. Conrey, and R. C. Wilson—"The Influence of Increased Positive "g" on Reaching Movements," *J. Appl. Psychol.*, 37, 1953, pp. 230-235.
9. P. A. Hunsicker—*Arm Strength at Selected Degrees of Elbow Flexion*, USAF, WADC Tech. Rep. 54-548, 1954.

New and powerful techniques for finding

Gear-Train Ratios

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The only systematic approach to solution of certain gear-ratio problems is offered by new methods presented here. Change-gear problems or ones involving complex tooth-number conditions are often difficult to solve by other methods.

Approximate a specified gear-train ratio, within close limits, quickly and easily—that's the job these new methods will do.

Fractions, obtained by transformation of the "rational plane," are the specific answers to specific gear-train problems. The rational plane is based upon a co-ordinate system in which properties of integers may be displayed. Any point on the plane represents a fraction.

The concept of the rational plane—a powerful graphic tool—was first announced in *MACHINE DESIGN* several years ago (References 1 and 2).

New techniques outlined here are based on these graphical notions. They eliminate inaccuracies of graphical methods and give even greater utility to the rational-plane concept.

IN THE design of gear trains, it is often necessary to find a rational number, N/D, that has a value close to that of a given real number, R, within a specified tolerance. The value of R, known from design considerations, may be either rational or irrational.

If R is a rational number, it is expressible as a fraction. However, its numerator or denominator may be of such size, or may contain such large prime factors, that an approximation is required.

For example, a simple spur train with a ratio $R = 0.908$ is needed. Number of teeth on any gear may not exceed 160 nor be less than 18. Since $R = 0.908 = 227/250$, and 227 is a prime number, no train satisfying specified limits on number of teeth is possible. It is then decided to tolerate an error not to exceed 0.00001. The four-gear train (50/56) (60/59) can then be found. It is in error by 0.0000097.

If R is an irrational number, it cannot be expressed as the ratio of two integers. Hence, no exact solution exists. For example, two dials must be geared together so that as one registers turns of a shaft, the other reads the angle in radians. The required ratio is $R = 2\pi$. Since π is irrational, no

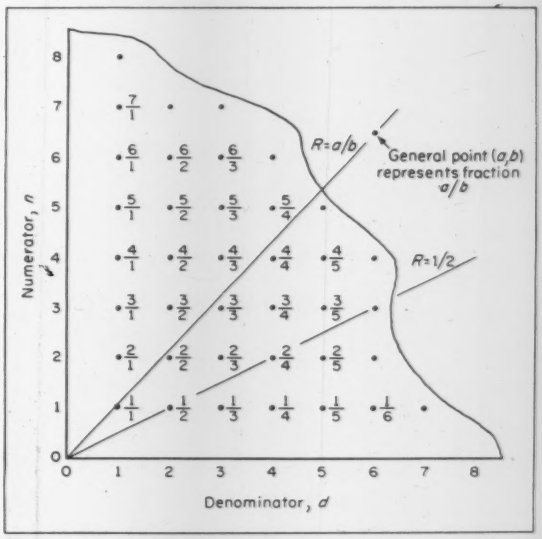

Fig. 1—The rational plane co-ordinate system. Every fraction n/d is represented once and only once in the plane by the point whose integral co-ordinates are n and d. A line, R, drawn through the origin and a point n/d will contain all equivalent fractions and no others. The point nearest the origin represents the fraction in lowest terms

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exact solution exists. An approximation which may be found acceptable is the six-gear train: (140/113) (120/40)(71/42). It is in error by 0.000009.

In both cases, a fraction which approximates the required R is sought. If the numerator and denominator each contain prime factors, all of which are smaller than the maximum permissible tooth number, an approximate train can be derived. If not (and there is no easy test which indicates that the terms of the fraction are not prime), then other approximating fractions must be sought.

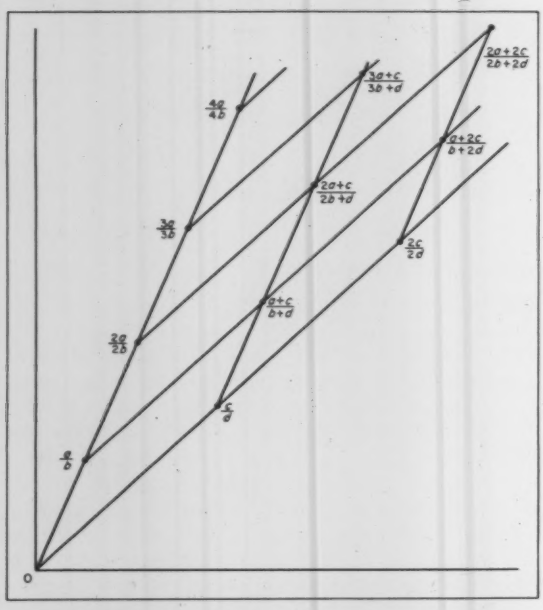


Fig. 2—Successive mediation between conjugate fractions a/b and c/d. The process of mediation fills the angular region with a lattice of parallelograms. Each rational number with a value between those of a/b and c/d appears at the intersection of some two lines. Conversely, each intersection in the lattice represents a rational number

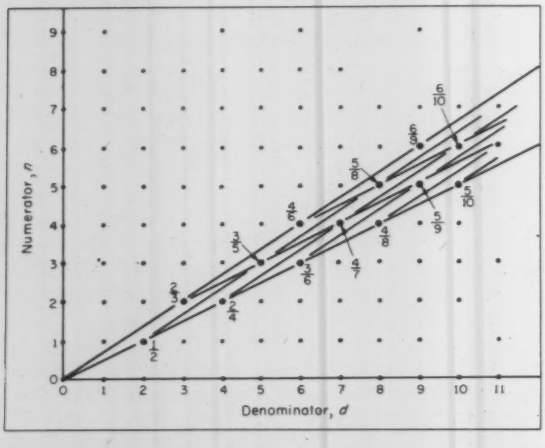


Fig. 3—Lattice of fractions between $a/b = 2/3$ and $c/d = 1/2$ formed by drawing parallels to lines 2/3 and 1/2

Best Approximation: The best approximation by a rational number to a real number, R, is defined as the fraction N/D of a value such that no other fractions closer in value to R, and with smaller terms N and D, exist. For example, 1365/1589 is a best approximation to 91/100 since no fraction exists between these which is closer in value to 91/100 or has terms smaller than those of 1365/1589.

Two rational numbers in lowest terms, a/b and c/d, each of which is a best approximation to the other, are distinguished by the property $ad - bc = \pm 1$. Such fractions are called conjugate fractions. For example, 29/49 and 16/27 are conjugate since $(29 \times 27) - (49 \times 16) = -1$.

Properties of Conjugate Fractions: Given two conjugate fractions, a/b and c/d, it is always possible to find a third fraction which is intermediate in value and conjugate to both. This fraction, $(a + c)/(b + d)$, is formed by adding the terms of the two given fractions. The process is called mediation and may be continued indefinitely. Mediation always fills the space between two adjacent fractions with one whose numerator is the sum of the adjacent numerators, and whose denominator is the sum of the adjacent denominators. Consequently, every fraction between a/b and c/d is of the form $(ay + cx)/(by + dx)$. The whole field of positive rational numbers may be generated by successive mediation between 0/1 and 1/0 on the rational plane.

A series of conjugate fractions may be formed by mediation between 1/1 and 0/1. If each fraction with a denominator larger than some value k is discarded, the resulting table is called variously a Farey series of order k, or a Brocot table of gear

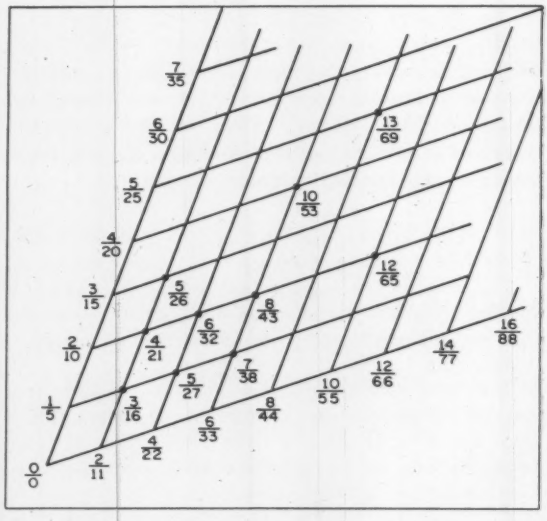


Fig. 4—Lattice of parallelograms based upon $a/b = 1/5$ and $c/d = 2/11$. The point at the intersection of lines 2/10 and 6/33 has the value $(2+6)/(10+33) = 8/43$. In practice, the angular region between 1/5 and 2/11 is thin

ratios. These tables are required for sample problems which follow.

The Rational or *R*-Plane: Points of the Cartesian plane whose co-ordinates are positive integers constitute the point lattice named the "rational plane." If each point (a,b) is associated uniquely with the rational number a/b (and conversely so), all rationals may be so represented, Fig. 1, and the plane exhibits in unambiguous manner all ratios which can be applied to the synthesis of gear trains. Alternately, a fraction a/b is represented by the line which extends from the origin (0,0) through a/b, $2a/2b$, $3a/3b$, . . . ta/tb. . . Both interpretations will be used interchangeably.

Extension of the Theory: Consider two conjugate fractions, a/b and c/d, and their mediate, $(a + c)/(b + d)$. With the origin, they form a unit parallelogram the interior of which contains no other point. Successive repetition of the operation of mediation fills the angular region between a/b and c/d with a lattice of parallelograms, Fig. 2. Each point between a/b and c/d (and therefore, each rational number between a/b and c/d) appears at the intersection of some two lines and, conversely, each intersection in the parallelogram lattice represents a rational number. This lattice then, is the analog in the R-plane of the Farey-Brocot series formed by successive mediation between a/b and c/d, If, for example, $a/b = 2/3$ and $c/d = 1/2$, the lattice structure formed by all intermediate fractions is as shown in Fig. 3.

Generally, the practical problem specifies a/b and c/d so near in value, that the triangular region between them is too thin to be useful for close graphical approximations, or for work with numbers as large as those required for finding approximations for trains of two or more meshes.

The Transform or *T*-Plane: The method which is the subject of this article consists of transforming the thin, triangular region between two conjugate fractions into a whole plane with mutually perpendicular axes.

Note that line $R = a/b$, Fig. 2, contains points $0/0$, a/b, $2a/2b$, $3a/3b$, and that line $R = c/d$ contains $0/0$ and all multiples of c/d. At each point on a/b there terminates a line which is parallel to c/d and, similarly, at each point on c/d there terminates a line which is parallel to a/b. Conversely, any point N/D within the region is projected into two points on lines a/b and c/d, and its numerator and denominator consist of the sums of the like terms of their projections. For example, in the lattice formed from $a/b = 1/5$ and $c/d = 2/11$, Fig. 4, the point at the intersection of lines 2/10 and 6/33 has the value $(2 + 6)/(10 + 33) = 8/43$.

If oblique lines a/b and c/d, which contain the parallelogram lattice between them, are rotated apart so as to become mutually perpendicular axes, the transformation is complete. Each point in the R-plane stands in a one-to-one correspondence with a point in the transformed plane or the T-plane. Values of the axes of each plane form the "basis" of the plane. Fig. 5 shows the two planes. The R-plane, with basis (1/0, 0/1) corresponds to the T-plane with basis (1/5, 2/11). Thus, 1/3 and 7/38, and 2/5 and 12/65 transform one into the other. Any fraction of the R-plane may be shown to "correspond" to a fraction in a similar position on the T-plane and vice versa.

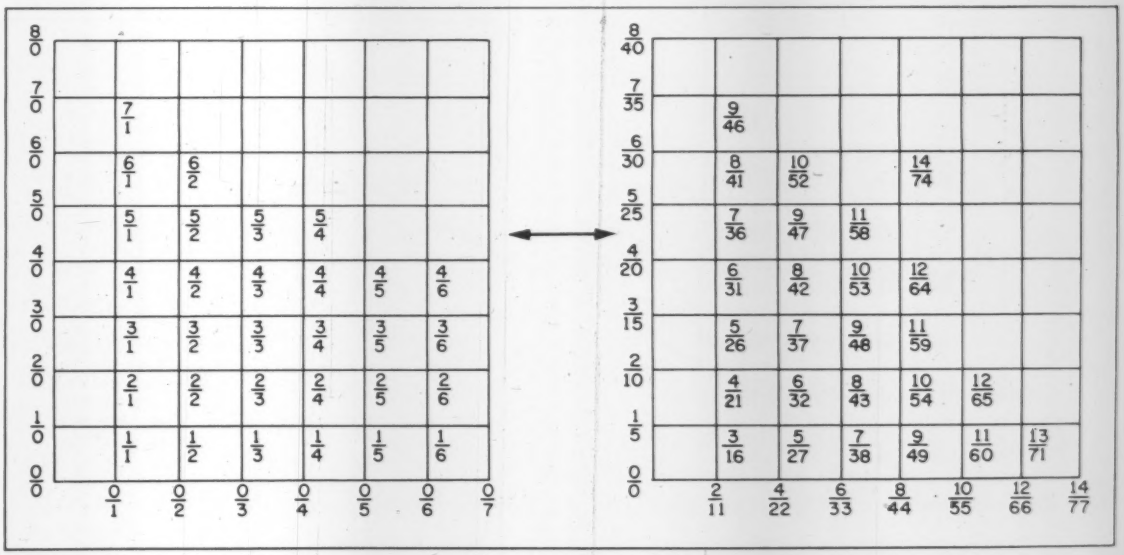


Fig. 5—Reciprocal relationship between the rational plane of fractions, left, and the transformed region between 1/5 and 2/11, right. The transformed region, or T-plane, was obtained from a lattice of parallelograms formed by successive mediation between 1/5 and 2/11 which correspond to a/b and c/d, respectively, of Fig. 2. Transformation is complete when the lines are made mutually perpendicular. Points in similar positions on each plane correspond

Equations of Transformation: As previously stated, a fraction N/D which is intermediate between two conjugate fractions, a/b and c/d, is of the form:

$$\frac{N}{D} = \frac{ay + cx}{by + dx} \quad (1)$$

This is the equation which transforms y/x into N/D. Reference to Fig. 5 shows that a fraction in the T-plane with basis $(a/b, c/d)$ is the transform of y/x in the R-plane. For example, $y/x = 2/5$ transforms by substitution in Equation 1 to obtain

$$\frac{N}{D} = \frac{1(2) + 2(5)}{5(2) + 11(5)} = \frac{12}{65}$$

An alternate form of the transformation is required when y/x is given in decimal form. Dividing both terms of the right member of Equation 1 by x and setting $z = y/x$,

$$\frac{N}{D} = \frac{az + c}{bz + d} \quad (2)$$

The inverse transformation is obtained by solving for z in Equation 2:

$$z = \frac{-cD + dN}{aD - bN} \quad (3)$$

The alternate form, in which the ratio N/D is given as a decimal, R, is

$$z = \frac{-c + dR}{a - bR} \quad (4)$$

Auxiliary Lines: When the conditions of a problem specify that N or D may not exceed certain limits, lines may be drawn on the transform plane in such a manner as to exclude all unacceptable fractions. From Equation 1, $N = ay + cx$ where a and c are numerators of the fractions chosen as the basis of the transform plane. Solving for y at $x = 0$ and for x at $y = 0$ gives y and x intercepts of the line representing a given N:

$$y \text{ intercept of } N\text{: } y = \frac{N}{a} \quad (5)$$

$$x \text{ intercept of } N\text{: } x = \frac{N}{c} \quad (6)$$

Similarly, from Equation 1, the intercepts of the line representing the limiting conditions on the denominator, $D = by + dx$, are found to be

$$y \text{ intercept of } D\text{: } y = \frac{D}{b} \quad (7)$$

$$x \text{ intercept of } D\text{: } x = \frac{D}{d} \quad (8)$$

General Problem: Assume that a gear train ratio R is specified and that it must be approximated by a fraction N/D within close limits. No ratio close enough appears in the gear tables, and a few preliminary trials at mediation have failed to produce a fraction which will factor into acceptable gear tooth numbers. Furthermore, the limits on ratio R are too close to discern when plotted graphically by the conventional rational-plane method.

SOLUTION: Select a basis from a set of gear tables which contains R. That is, choose two fractions, a/b and c/d, conjugate to each other and such that the value of R lies between them. Mark off the axes of the T-plane on a sheet of graph paper with

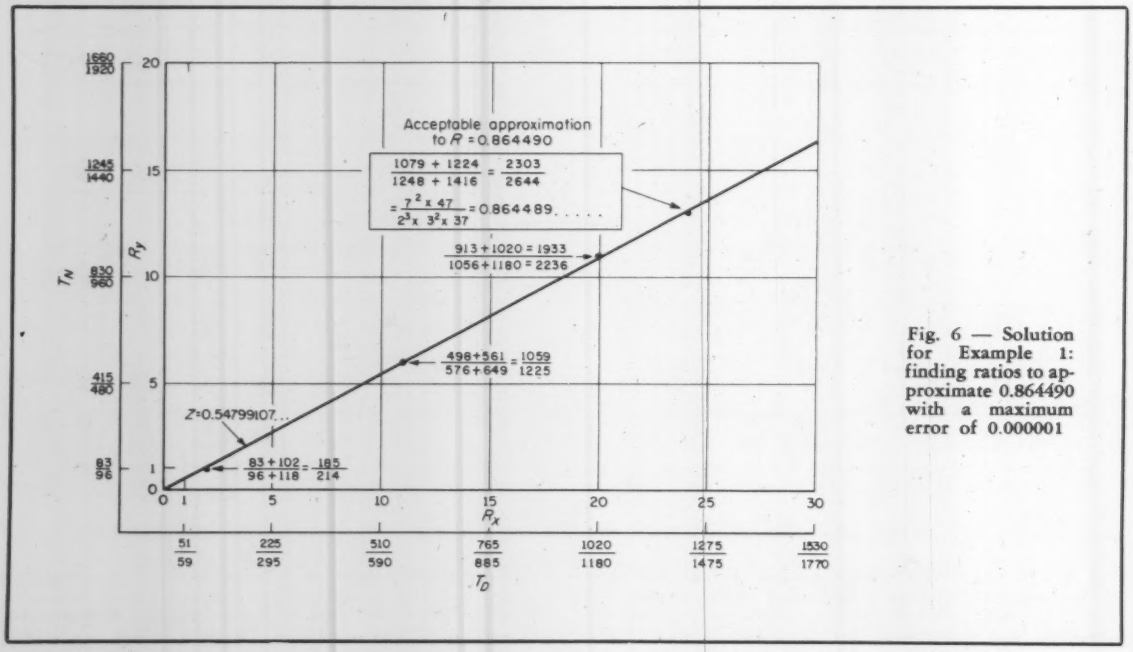


Fig. 6 — Solution for Example 1: finding ratios to approximate 0.864490 with a maximum error of 0.000001

the points 0/0, a/b, $2a/2b$, $3a/3b$, . . . ay/by . . . and 0/0, c/d, $2c/2d$, $3c/3d$ . . . cx/dx . . .

Consider the T-plane to be superimposed upon the R-plane, and simultaneously mark the R-plane co-ordinates upon the axes. Substitute the terms of the basis and the given R into Equation 3 or Equation 4, and solve for z. Draw a line having slope z through the origin.

The T-plane points nearest the line z are the fractions nearest in value to that of the required R. Determine values of these fractions by adding the corresponding terms of their co-ordinates. Test the fractions by factoring to determine applicability to the particular design problem.

When upper and lower limits on R are given, solve for z corresponding to both of these limits and draw both lines through the origin. When limits on the size of N and D of the desired fraction are known, draw the auxiliary lines given by Equations 5, 6, 7, and 8. The acceptable fractions are represented by points within the regions bounded by these lines.

Example 1: Design a spur gear train with a ratio $R = 0.864490$. The ratio must be within a maximum error of 1 in the sixth decimal place. Number of gear teeth may not exceed 80 nor be less than 18.

SOLUTION: Consult a table of gear ratios for a possible single-mesh solution. The desired ratio is found to be between $83/96 = 0.864583$ . . . and $51/59 = 0.864406$ . . . Neither of these yields an acceptable solution.

Choose these fractions as the basis for the T-plane into which the R-plane of fractions will be transformed. Note that the requirement that the basis be conjugate is satisfied by adjacent fractions in a gear table. In this particular case, $(83 \times 59) - (51 \times 96) = +1$.

Select a quarter-inch linear graph paper and mark off the co-ordinate axes. Adjacent and parallel to the R-plane co-ordinates on the y-axis (0, 1, 2, . . . n, . . .), place the corresponding T-plane co-ordinates, 0/0, 83/96, 166/192, 249/288 . . . 83 n/96 n, . . . Similarly, place the T-plane co-ordinates which correspond to the x-axis co-ordinates (0, 1, 2, . . . n, . . .) on an adjacent and parallel scale, 0/0, 51/59, 102/118, 153/177, . . . $51n/59n$ . . .

To draw the line which represents R, first calculate its transform, z, from Equation 4. Let $a = 83$, $b = 96$, $c = 51$, $d = 59$, and $R = 0.864490$. Then, $z = 0.54799107$ . . .

Draw the line with slope z through the origin of the R-plane co-ordinates, Fig. 6. Points which lie closest to this line represent fractions which are close to the required ratio R. Test these

Table 1—Some Solutions for Example 1

Fraction R-Plane	Fraction T-Plane	Factors	Decimal Equivalent
2/1	185/214	(5×37)/(2×107)	0.8644855 . . .
6/11	1059/1225	(3×353)/(5×5×7×7)	0.8644897 . . .
11/20	1933/2236	1933/(2×2×13×43)	0.8644901 . . .
13/24	2303/2664	(7×7×47)/(2×2×2×3×3×37)	0.8644894 . . .
16/29	2807/3247	(7×401)/(17×191)	0.8644903 . . .
17/31	2992/3461	(2×2×2×2×11×17)/3461	0.8644900 . .
23/42	4051/4686	5051/(2×3×11×71)	0.8644899 . . .

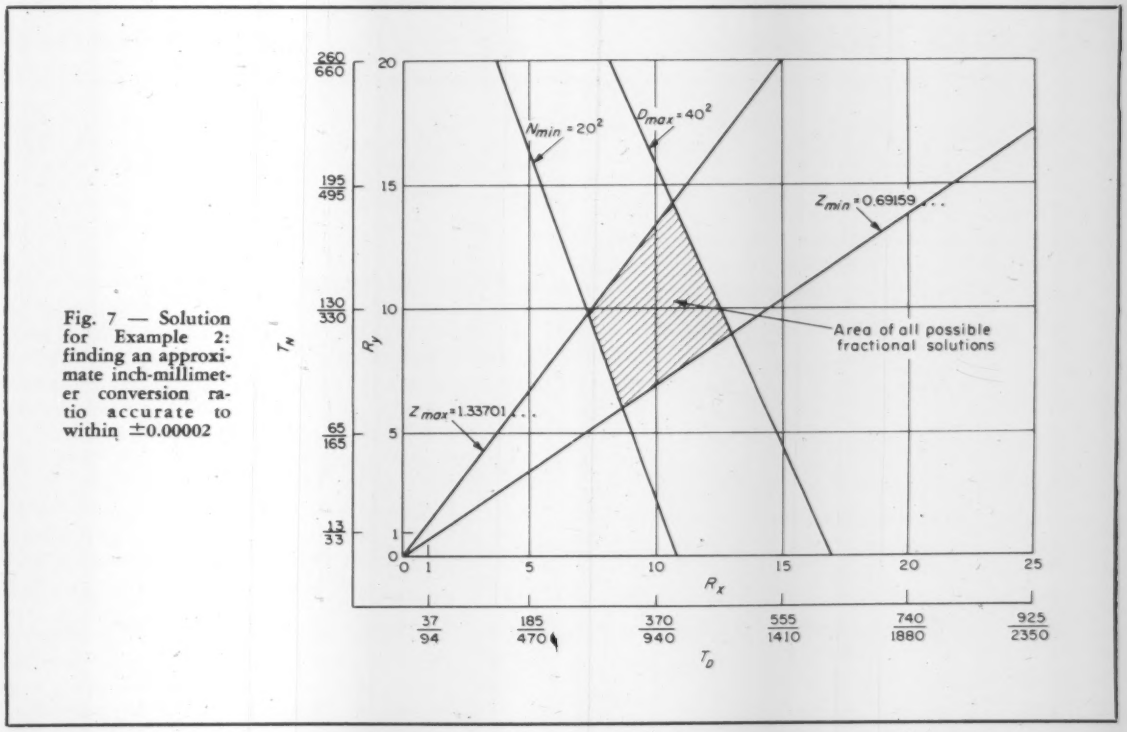


Fig. 7 — Solution for Example 2: finding an approximate inch-millimeter conversion ratio accurate to within ±0.00002

fractions for their factorability into numbers between 18 and 80 inclusive. Some of the points selected are given in Table 1.

All of these are well within the specified limits of accuracy. One of them, 2303/2664, yields an acceptable two-mesh gear train: (49/72)(47/37). It is in error by 0.00000052. Many others may be selected from the graph.

Example 2: A machine tool designed to cut a thread in the inch system of measurement must be geared to cut a millimeter thread. A gear train with $R = 0.3937$ is required. Number of teeth in any gear may not exceed 40 nor be less than 20, and ratio accuracy must be within ± 0.00002.

SOLUTION: An exact solution is not possible since $3937 = 31 \times 127$, and 127 is larger than 40, the maximum permissible tooth number. A single-mesh solution is not possible either, since the closest fractions to R with denominators not exceeding 40 are outside the tolerance limits on R, $13/33 = 0.39393\ldots$ and $11/28 = 0.39285\ldots$

These two fractions might be chosen as a basis for the T-plane since they are conjugate. However, to achieve a greater expansion and to place R in the approximate midrange of the basis, the second fraction is replaced by 37/94 which is found by mediating twice between 13/33 and 11/28. The basis, then, is $13/33 = 0.393939\ldots$ and $37/94 = 0.393617\ldots$ On graph paper, draw the axes and number the co-ordinates as in Example 1. Apply the tolerance to the ratio to obtain $R_{max} = 0.39372$ and $R_{min} = 0.39368$.

Letting $a = 13$, $b = 33$, $c = 37$, and $d = 94$, solve for z_{max} and z_{min}, Equation 4, to obtain $z_{max} = 1.33701$ and $z_{min} = 0.69159$. Draw the lines with slopes corresponding to these values of z, Fig. 7.

From Equations 5 and 6, solve for x and y intercepts of the line representing the minimum numerator, $N_{min} = 20^2 = 400$: $y = N/a = 400/13 = 30.8$, and $x = N/c = 400/37 = 10.8$. Draw the line N_{min} to intersect the x-axis at $x = 10.8$ and the y-axis at $y = 30.8$.

In a similar manner, solve for the intercepts of $D_{max} = 40^2 = 1600$ using Equations 7 and 8: $y = D/b = 1600/33 = 48.5$, and $x = D/d = 1600/94 = 17.0$. Draw the line D_{max} to intersect the x-axis at $x = 17$ and the y-axis at $y = 48.5$.

The quadrilateral region within these four lines contains all possible fractional solutions. An examination of each of the 26 fractions reveals that none of them factors into numbers within the limits on the tooth numbers specified in the problem. Consequently, no solution exists.

If the requirements were relaxed to permit a 19-tooth pinion, the fraction 437/1110, found at $y/x = 7/9$ and formed by adding the corresponding terms of the T-plane fractions 104/264 and 333/846, will factor to yield an acceptable combination, (19/30)(23/37). The error of this approximation is 0.0000068, well within the specified tolerance range.

REFERENCES

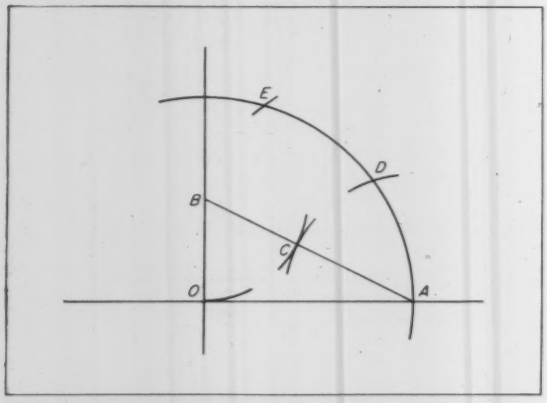
Cited references are those of the author, Arne Benson, and appeared in past issues of MACHINE DESIGN, as follows:

1. "Gear Ratios," Vol. 28, No. 4, February 23, 1956, pp. 103-107.
2. "Gear Ratios," Vol. 28, No. 5, March 8, 1956, pp. 108-112.

Tips and Techniques

Construction of a Regular Decagon

A simple way to construct a regular decagon consists of drawing a circle with radius OA and making the following line constructions. Draw OB one half the length of OA, and perpendicular to it. On AB lay out the distance BC equal to BO. Length AC is the length of each side of the decagon (AD, DE, etc.), or distance between vertexes.—GEORGE EHRENFRIED, *Cambridge, Mass.*



Cosines of Small Angles

By applying a trigonometric identity, cosines may be found to four or five significant figures. When A is small, $\cos A = 1 - \tan (A/2) \sin A$. Since for small angles $\tan A/2 = \sin A/2$, substitution gives: $\cos A = 1 - \sin A \sin (A/2)$.

To find the cosine on a slide rule, set index of slide at $\sin A/2$ on D scale. Move indicator to A on ST or S scale and read product of sines on D scale, paying close attention to position of decimal. Subtract this value from one to determine desired cosine.

For example, to find cos 5 deg, set index at sin 2.5 deg = 0.0436. Under 5 deg on ST scale read 0.0038. Therefore, cos 5 deg = 1.0000 − 0.0038 = 0.9962. Tables of natural functions give cos 5 deg = 0.99619.—C. A. MARMELSTEIN JR., *Atlanta, Ga.*

DESIGN ABSTRACTS

electrical

Aircraft Switching Type Static Invertors

K. M. Chirgwin, Jack & Heintz Inc.

A discussion of the probable behavior of future high-power static invertors with aircraft type loads, with emphasis on the problems involved and anticipated when the load includes rotating machines. Types of switching devices and motor starting problems are covered.

AIEE paper 58-828, "Aircraft Switching Type Static Invertor Supplying Rotating Machines," from AIEE Summer General Meeting, Buffalo, June, 1958; 7 pp.

High-Efficiency Mag Amplifier

C. L. Boyajian, General Electric Co.

A description of a dc push-pull magnetic amplifier which is used to drive a dc shunt motor. The paper demonstrates the practicality of applying magnetic amplifiers to driving dc motors in reversible operations. General operating characteristics of the circuit and problems associated with driving a dc motor load are covered. Also included are factors which influence design of the circuit. Data presented are the results of actual applications.

AIEE paper 58-775, "High Efficiency Push-Pull Magnetic Amplifier and Its Use as a DC Shunt Motor Drive," from AIEE Summer General Meeting, Buffalo, June, 1958; 10 pp.

Thermal Impedance Of Cooling Fins

E. J. Diebold and W. Luft, International Rectifier Corp.

A presentation of heat transfer characteristics of cooling fins. A method of approach is suggested for determining thermal impedance by a nonanalytical method. By computing valid curves of normalized variables, analysis is minimized and simple relations for design parameters are established. Optimum design proportions of cooling fins are obtained without the trial and error approach.

AIEE paper 58-926; from AIEE Summer General Meeting, Buffalo, June, 1958; 18 pp.

Recommended Symbols For Magnetic Amplifier Papers

H. F. Storm, General Electric Co.

A compilation of standardized magnetic amplifier symbols aimed at introducing uniformity into magnetic amplifier literature. Included are lists of previously standardized symbols, additional symbols, and lower and upper case subscript use.

From AIEE Conference for Nonlinear Magnetics and Magnetic Amplifiers, Los Angeles, August, 1958; 5 pp.

finishes

Significance of Surface Finish By Electro-Discharge Machining

Charles H. Good, Micrometrical Development Corp.

A description of the electro-discharge machining process and surface finishes which can be attained by it. Recommended finishes for various components are listed in table form. The EDM process finish is compared with those of other machining processes.

ASTE paper 89, from ASTE 26th Annual Meeting, Philadelphia, May, 1958; 5 pp.

How To Specify Honed Finishes

B. R. McConnell Sr., Sunnen Products Co.

A description of the honing process and factors which affect surface finishes. Recommended honed finishes for hard and soft steels, cast iron, and other nonferrous materials are included. How grit size, nature of work material, and type of grit affect surface finish is explained. Specifications and their meanings are defined.

ASTE paper 78, from ASTE 26th Annual Meeting, Philadelphia, May, 1958; 4 pp.

A New Approach to Improving Gear Surface Finish

B. F. Bregi, National Broach & Machine Co.

A description of the gear-tooth honing process, its applications, and the advantages it offers. Typical gear-tooth surface finishes before and after honing are compared. Honing equipment is described.

ASTE paper 77, "Gear Tooth Honing —A New Approach To Improving Gear Surface Finish," from ASTE 26th Annual Meeting, Philadelphia, May 1958; 9 pp.

techniques

Static Switching For the Mechanical Engineer

Arthur H. Wolfson, Pratt & Whitney Co. Inc.

A description of basic logic elements and how they are used. Application to automatic machine sequences are explained. Operation is explained by

showing how logic elements are used in automatic gage control circuits. Advantages of logic elements over relays are discussed.

ASTE paper 73, from ASTE 26th Annual Meeting, Philadelphia, May, 1958; 4 pp.

Design Parameters for Electric Motor Actuators

Howard C. Zachmann, The Martin Co.

An approach to design problems of electromechanical actuators which takes into consideration combinations of environment and performance requirements. Design information permits an applications engineer to integrate a balanced system.

AIEE paper 58-833, from AIEE Summer General Meeting, Buffalo, June, 1958; 11 pp.

A Computer Method For Network Design

J. Robert Logan, Litton Industries

A description of a system of operations which converts mathematical system equations to a set of reduced logical equations. The logical equations then provide a means with which to accomplish the task indicated by the original equations. Logical designs laid out by this technique are intended mainly for special-purpose equipment, or select components of general-purpose machines. The method is useful, since design and design modifications can be reduced to computer setup routines.

From 5th Annual Symposium on Computers and Data Processing, sponsored by Denver Research Institute, Denver, July, 1958; 20 pp.

processes

Effect of Shot Peening On Fatigue Strength

R. P. Felgar, General Electric Co.

An evaluation of three effects of shot peening: Cold working, residual stress, and stress concentrations. Relation of these effects to fatigue strength is discussed. Influence of induced residual stress on fatigue strength is predicted on the basis of a concept which permits determination of the strength of manufactured components. It is shown that these predictions agree closely with observed values. Effects of shot size used in peening on fatigue limit is demonstrated.

ASME paper 58-SA-46, from ASME Semiannual Meeting, Detroit, June, 1958; 9 pp.

Application Of Radial Draw Forming

L. A. Allison, Cyril Bath Co.

Advantages and limitations of the radial draw forming process. Design and production opportunities are stressed, and design techniques for various cross sections are illustrated. Resultant economies of the process are covered.

SAE paper 65C, "Application of Radial Draw Forming Process to Automotive Components," from SAE Summer Meeting, Atlantic City, June, 1958; 6 pp.

Effect of a Lead Additive On Machinability of Alloy Steel

N. Zlatin and J. Gould, Metcut Research Associates Inc.

A report on the use of a lead additive as a means of alleviating machining problems at high hardnesses. Data are the result of tests with carbide tools on medium-carbon steel at several different hardness levels. Data show at what hardness levels the lead additives are most effective. Attainable surface finishes are covered.

ASME paper 58-SA-53, from ASME Semiannual Meeting, Detroit, June 1958; 6 pp.

Relation of Shot Peening To Gear-Tooth Scoring

John C. Straub, Wheelabrator Corp.

A discussion of the possible influence of shot peening on scoring tendencies of gears. Gear-tooth failures are classified by major types and relationship of design to type of failure is shown. Influence of peening on physical properties of gears is covered as well as specifications for shot peening.

ASLE paper 58AM 6B-3, "Shot Peening in Relation to Gear Tooth Scoring," from ASLE 13th Annual Meeting, Cleveland, April, 1958; 9 pp.

materials

Iron-Aluminum Base Alloys

Blake King, J. Mueller, N. Ida, and F. Tate, The Martin Co.

A discussion of the characteristics and properties of iron-aluminum base alloys which liken them to economical "stainless" alloys. Properties of experimental alloys are compared to those of stainless steel, and plans for further development are discussed.

SAE paper 60B, "Iron-Aluminum Base Alloys—Cheap Stainlesses of the Future?" from SAE Summer Meeting, Atlantic City, June, 1958; 9 pp.

Silicone Insulation

Lee A. Teichthesen, Dow Corning Corp.

An evaluation of silicone insulation systems for various types of enclosed motors. Although report is based on experiments with mine motor insulation, data are applicable to other types. Suitability of silicone insulation for dc motors is discussed.

AIEE paper 58-762, from AIEE District Meeting, Huntington, W. Va., May, 1958; 11 pp.

Hypereutectic Aluminum-Silicon Alloys

Richard Smith, Aluminum Co. of America.

Physical and mechanical properties and wear characteristics of aluminum-silicon alloys which contain more than the eutectic quantity of 11.6 per cent silicon. Suitability of these alloys for such parts as pistons, cylinder liners, cylinder blocks, and brake drums, for example, are discussed. Results of wear performance of an aluminum-silicon alloy used as cylinder liners are included and potential applications are mentioned.

SAE paper 65A, from SAE Summer Meeting, Atlantic City, June, 1958; 8 pp.

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

Denver Research Institute, University of Denver, Denver 10, Colo.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; papers 35 cents to members, 50 cents to nonmembers.

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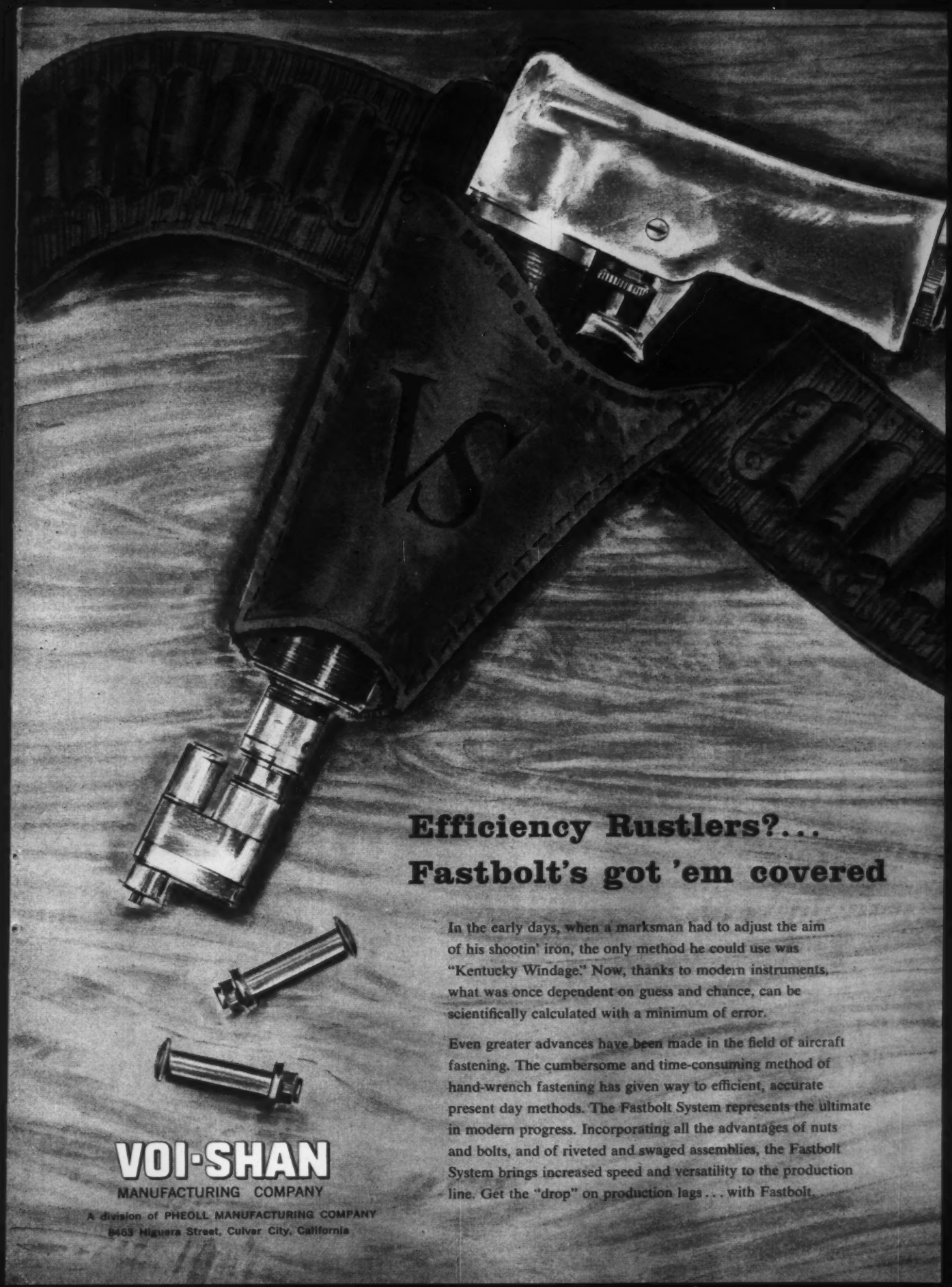

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Engineering and selection information are content of Catalog 5802 on Speed-Master gear reducer line. Wide range of ratios and ratings up to 10,000 hp is offered with various shaft arrangements. All models have double helical hardened gear and heavy duty antifriction bearings. Western Gear Corp., Box 182, Lynwood, Calif. L

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Electrical Fittings

Complete design and application data, including prices, are contained in Catalog 140 on conduit fittings, electrical connectors, cast boxes, and interlocked armor cable fittings. Dimensions, electrical characteristics, and construction details are included. 96 pages. O. Z. Electrical Mfg. Co., 262 Bond St., Brooklyn 17, N. Y. D

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Selenium rectifiers for arc suppression in electric control components are detailed in illustrated bulletin. Physical and electrical characteristics of these vacuum-processed units for ac and dc use are covered. 4 pages. Bradley Laboratories, Inc., New Haven 11, Conn. B

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Magnet Design

Bulletin No. 13 is entitled, "Permanent Magnet Design." It discusses applications, fundamental properties, problems of magnet design, testing, magnetic attraction, mechanical considerations, permanent magnet materials, Alnico grades, and data required for quotations or design recommendations. 20 pages. Thomas & Skinner, Inc., 1120 E. 23rd St., Indianapolis 7, Ind. J

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Microwave Equipment

Microwave and electronic equipment for military and commercial systems, antennas and components, microwave subsystems, field and depot testing equipment, laboratory instruments and standards, and automatic checkout equipment are described in Catalog "Microline Equipment." 12 pages. Sperry Microwave Electronics Co., Clearwater, Fla.

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Use of thermistors has been extended by new units which function continuously at temperatures to 1200° F. Details of these electronic components are given in Catalog EMC-2. Fenwal Electronics, Inc., Mellen Street, Framingham, Mass. B

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Mechanical Steel Tubing

Comprehensive "Handbook of Cold Drawn, Buttweld Mechanical Steel Tubing" describes the manufacture, uses, and economies of this material in industry. Pertinent metallurgical, mechanical, and engineering properties are included. 60 pages. Pittsburgh Tube Co., 212 Wood St., Pittsburgh 22, Pa. F

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Polypropylene Uses

Broad range of commercial applications for Pro-Fax polypropylene plastic is included among information provided in technical booklet 500. Available in three types and a range of colors, plastic has good mechanical and electrical properties and exceptional chemical and heat resistance. Processing and fabrication are covered as well. 12 pages. Hercules Powder Co., Ninth & Market Streets, Wilmington 99, Del. C

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Hydraulic Pumps

Engineering and design data on Series T, compact, integral pump and motor units for hydraulic, pressure feed, and transfer work are contained in Bulletin 31. Pumps are rated 0.3 to 55 gpm with pressure ratings to 400 psi. 8 pages. Roper Hydraulics, Inc., Rockford, Ill. K

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Pressure Reducing Valve

The OPW-Jordan sliding gate pilot-operated pressure reducing valve for steam, water, oil, gas, air, or chemical service is detailed in Bulletin J-1160. Valves are made for up to 250-psi inlet pressures. 4 pages. Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

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Conveyor Chain

Easier cleaning of streamlined undersurface, and up to 35 per cent greater rail bearing area are achieved by projection welded Duraweld conveyor chain. Folder 1058D points up features and provides dimensional data on this conveyor chain for intra-machine product handling. 4 pages. Diamond Chain Co., Indianapolis 7, Ind. J

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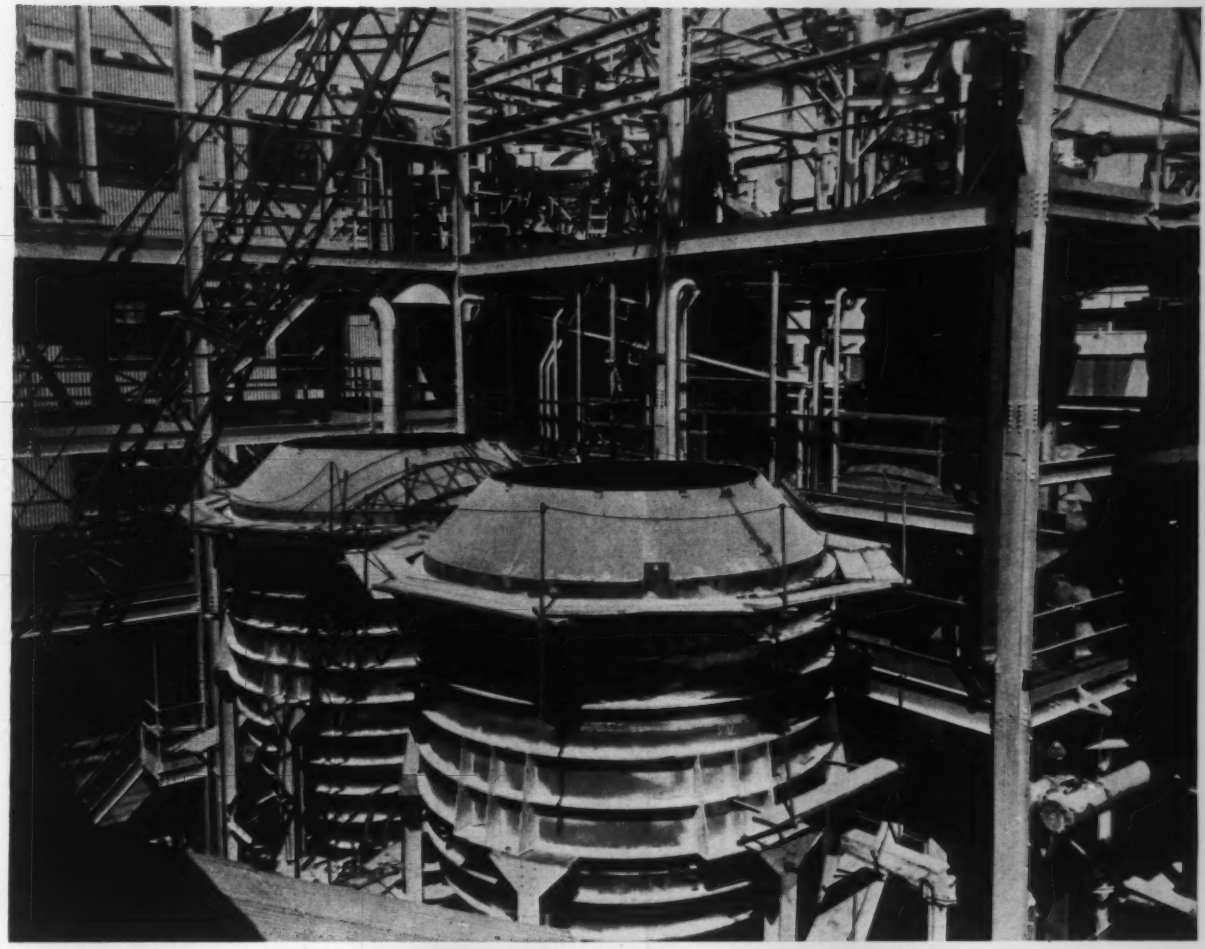
Circle 636 on Page 19

Water Instruments

Propeller meters and other water measurement and recording instruments are described and illustrated in Bulletin 314-1. Principles of propeller metering and performance graphs are covered as are recorders and their application, remote controlling, and accessories. 20 pages. Sparling Meter Co., 225 N. Temple City Blvd., El Monte, Calif. L

Circle 637 on Page 19



The potash crystallizers under construction above are two of seven that were shop- and field-fabricated, then field-assembled by welding. Although these units were not stress-relieved or heat-treated, there was no sign of stress-corrosion cracking after a year.

No stress-relieving here —no stress-corrosion cracking!

Field-assembled from NEW AMPCO METAL GRADE 8

Improved Ampco Metal Grade 8 puts an entirely new slant on fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

At a major oil refinery, for example, field-welded piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-cracking.

New, patented Ampco Metal Grade 8 also simplifies field repairs and alterations. You can weld readily with any electric process, without pre-heat or post-heat and without hot-short cracking.

Talk this over with your Ampco field engineer. Or write *Ampco Metal, Inc., Dept. 34-I, Milwaukee 46, Wis. West Coast plant: Burbank, Calif. — Southwest plant: Garland (Dallas County), Texas.*

TS-6

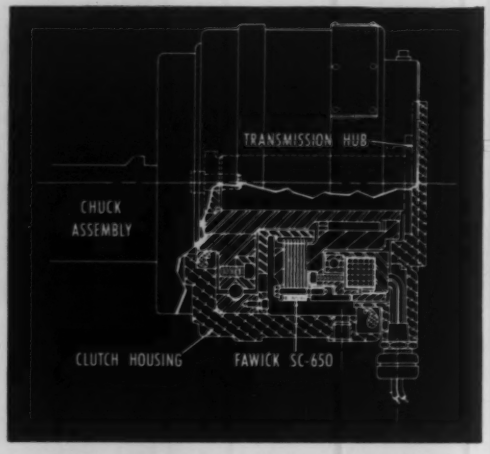
AMPCO®

Aeroquip Model F-2152 assembles and disassembles Aeroquip Flexible Hoses and standard fittings. These assemblies are widely used in aircraft, industrial, farm, marine and railroad applications.

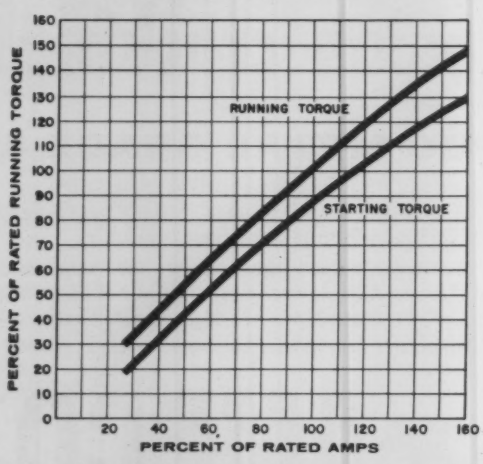
precision torquing on Aeroquip Hose Assembly Machines

...with Fawick SC Magnetic Clutches

Regulation of current to clutch controls tightening of hose fittings, improves machine efficiency



Drawing shows application of the Fawick SC-650 Magnetic Clutch in the Aeroquip Model F-2152 Hose Assembly Machine. Clutch housing is filled with SAE No. 10 oil.



Curves show the direct relationship between current input and torque capacity of Fawick Magnetic Clutches.

Aeroquip Corporation's new Hose Assembly Machines, using Fawick Magnetic Clutches, tighten various size hose fittings to the exact degree of tightness required. Torque control is accomplished by regulating current to the clutch. With each change of hose and fitting size, the operator repositions a powerstat control dial to the predetermined torque requirement. The Fawick Clutch delivers desired driving power . . . then accurately slips when the assembly has been correctly tightened.

According to Aeroquip Chief Tool Engineer W. R. Cowan, "Fawick Clutches were selected because they proved capable of maintaining consistent torque characteristics. We found we could depend upon them for accurate control of tightening needed to make our assembled products safe and reliable."

Aeroquip Corporation (Jackson, Michigan) is one of the many builders and users of precision machinery who are discovering the performance and design advantages of Fawick Magnetic Clutches. Models are available with diameters from 2 to 13 inches, torque ratings from 36 to 48,000 in.-lbs. The new Bulletin M-101-A contains complete information. Write for your copy today.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Hunt St., West
Toronto, Ontario, Canada

FAWICK Magnetic
INDUSTRIAL CLUTCHES AND BRAKES

Circle 496 on Page 19

Hose Fitting Adapters

Expanded line of adapters for reusable Hoze-lok fittings for industrial hose is presented in Catalog 4490. Various styles of connectors for male pipe threaded ends and swivel nut ends are included. Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 638 on Page 19

Vacuum Metallizing Coatings

"Vacuum Metallizing Coatings for Metal, Glass & Thermosetting Plastics" is title of brochure describing various coating application procedures as well as coatings used in conjunction with vaccum metallizing. 16 pages. Bee Chemical Co., 12933 S. Stoney Island Ave., Chicago 33, Ill. J

Circle 639 on Page 19

Silicone Fluids

Entitled, "An Engineering Guide to Silicone Fluids for Mechanical Applications," Bulletin 3-112 discusses the use of these fluids in viscous damping, springing, coupling, and related mechanical applications. 8 pages. Dow Corning Corp., Midland, Mich. H

Circle 640 on Page 19

Ventilating Units

Bulletin FP-101 descriptively covers Fan Pac ventilating units in both direct-driven and belt-driven models. Two sizes specified are rated ¾ and 1 hp respectively, with capacities to 1500 and 1800 cfm. 4 pages. General Blower Co., Morton Grove, Ill. J

Circle 641 on Page 19

Knitted Metal Mesh

"Knitted Mesh—Its Properties and Uses" describes knitted metal mesh and outlines briefly how and where it can be used. Air filter, resilient medium, acoustical, insulating, gasketing, and radio noise suppression applications are covered. 8 pages. Metal Textile Corp., Roselle, N. J. D

Circle 642 on Page 19

Stainless Steel

Type 304L and 316L extra-low-carbon (ELC) stainless steels are described in illustrated booklet as a simple and economical means of preventing carbide precipitation in stainless steel weldments. Chemical analyses and typical mechanical properties are given and applications are shown. 8 pages. Armco Steel Corp., 1258 Curtis St., Middletown, Ohio. G

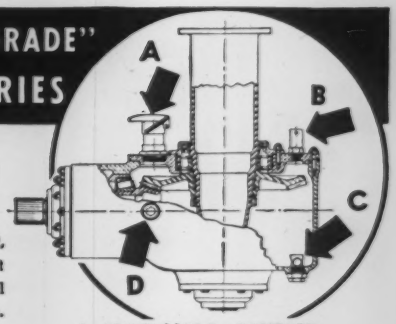
Circle 643 on Page 19

Roller Chains

Detailed engineering data illustrating a wide range of roller chain applications are found in Book 2657, "Link-Belt Precision Steel Roller Chains and Sprockets." Typical installation conditions, formulas, charts, and diagrams to aid in selection are included in the "keydexed" book. Lubrication, maintenance, and sprocket engineering are covered. 154 pages. Link-Belt Co., Prudential Plaza, Chicago 1, Ill. J

Circle 644 on Page 19

TEDECO "AVIATION GRADE" GEAR CASE ACCESSORIES



A—FILLER CAPS B—BREATHER VENTS C—DRAIN PLUGS D—OIL SIGHT GLASSES—ALSO LUBRICATION JETS, DRAIN LINES, ETC.

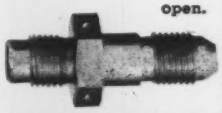
SELF CLOSING MAGNETIC DRAIN PLUGS

Permit convenient, direct, visual inspection without loss of fluid, no special tools, no electric gadgets. Automatic valve closes when magnetic plug is removed. Matching drain lines available.

THREADED OR BAYONET

GEAR CASE FILLER CAPS

Precision made of pressure die cast aluminum alloy. Short or long neck models. Snap closed, stay closed. Snap open, stay open.



LIQUID LEVEL SIGHT PLUGS

Reflector assures visibility even in dark areas. Shows median level in agitated fluids. Easily installed in tapped holes.

BREATHER VENTS

Designed with internal baffles against oil spillage and with effective metal filters. Conform to aircraft specifications.

Send for our complete catalog with working drawings of all sizes. Engineering service available.

TECHNICAL DEVELOPMENT COMPANY
305 SOUTH CHESTER PIKE, GLENOLDEN, PA.

Circle 497 on Page 19

TOUGH and tiny

save SPACE and WEIGHT with The A. W. HAYDON COMPANY'S Unique Line of RELIABLE SUB-MINIATURE TIME DELAY RELAYS

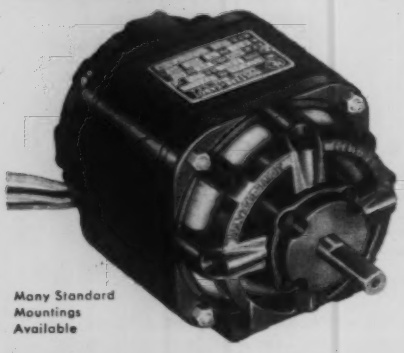
TINY!
1 x 2 inch cross section
7½ ounce basic weight

TOUGH!
Temperature: -54° C. to 85° C.
Vibration: 500 CPS, 10g
Shock: 30g
Hermetically Sealed Housings!
Direct Current or 400 Cycle Operation!
Standard or Reverse Clutching!
Custom Designed to Meet Military Specifications!
Write for Bulletin AWH-TD-502.

The A.W. HAYDON Company
249 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

Circle 498 on Page 19

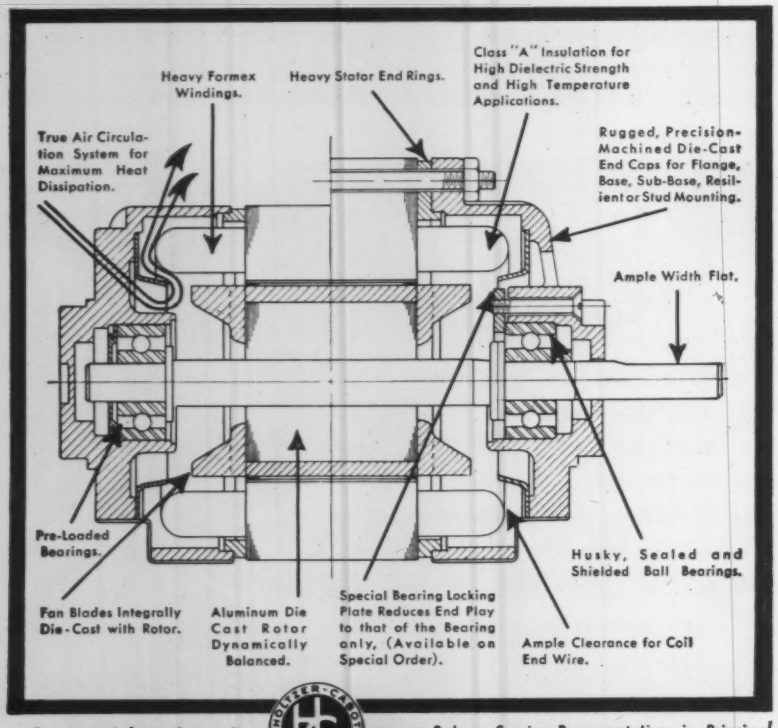
New Designs in Motors from HOLTZER-CABOT



Many Standard Mountings Available

TYPE R-29 MOTOR
2⅞" Diameter

This motor is an ideal power source for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communications equipment, etc. It is available in both 2-pole and 4-pole design, each in three stacking lengths. Type R-29 is a permanent split capacitor type available as an induction or synchronous motor. H.P. of various models ranges from 1/75 to 1/30. Construction features are indicated below.


Heavy Formex Windings.
Heavy Stator End Rings.
Class "A" Insulation for High Dielectric Strength and High Temperature Applications.
True Air Circulation System for Maximum Heat Dissipation.
Rugged, Precision-Machined Die-Cast End Caps for Flange, Base, Sub-Base, Resilient or Stud Mounting.
Ample Width Flat.
Pre-Loaded Bearings.
Husky, Sealed and Shielded Ball Bearings.
Fan Blades Integrally Die-Cast with Rotor.
Aluminum Die Cast Rotor Dynamically Balanced.
Special Bearing Locking Plate Reduces End Play to that of the Bearing only, (Available on Special Order).
Ample Clearance for Coil End Wire.

For more information, write, or use Readers' Service Card.

Sales — Service Representatives in Principal Cities throughout the World

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston, Massachusetts

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

Circle 499 on Page 19

HELPFUL LITERATURE

Gyroscope Primer

Lively cartoon treatment is used to illustrate the "Gyro Primer" which explains how gyros work, pertinent terms, and operating principles. Specifications for rate, free, directional and compensated vertical gyros are included. 64 pages. United Aircraft Corp., Norden Div., Commack, Long Island, N. Y. D

Circle 645 on Page 19

Adjustable Speed Drives

Illustrated Bulletin D-2506 describes V-S Drives which provide precise, adjustable machine speeds from in-plant alternating current circuits. How they operate and may be applied to various types of machinery are detailed. Condensed specifications are included. 16 pages. Reliance Electric & Engineering Co., 24701 Euclid Ave., Cleveland 17, Ohio. F

Circle 646 on Page 19

Light Flashers

Specifications sheets 399-100 and 396-100 give information on a Mil Spec. qualified flasher and a transistorized flasher for use with indicator lights. 2 pages each. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

Circle 647 on Page 19

Flow Regulators

Full range adjustable, limited range adjustable, and factory set fixed flow pressure-compensated flow regulators for hydraulic power systems are subject of illustrated Catalog 1000. Most of shown units are rated at 3000 psi and have 0.1 to 100 gpm flow rates. 16 pages. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill. J

Circle 648 on Page 19

Safety Relief Valves

Diagrams and basic facts on selection and installation of 230 and 240 Series safety relief valves for hot water space heating boilers are content of Bulletin P-33. Table lists complete line. 4 pages. McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago 18, Ill. I

Circle 649 on Page 19

Selenium Rectifiers

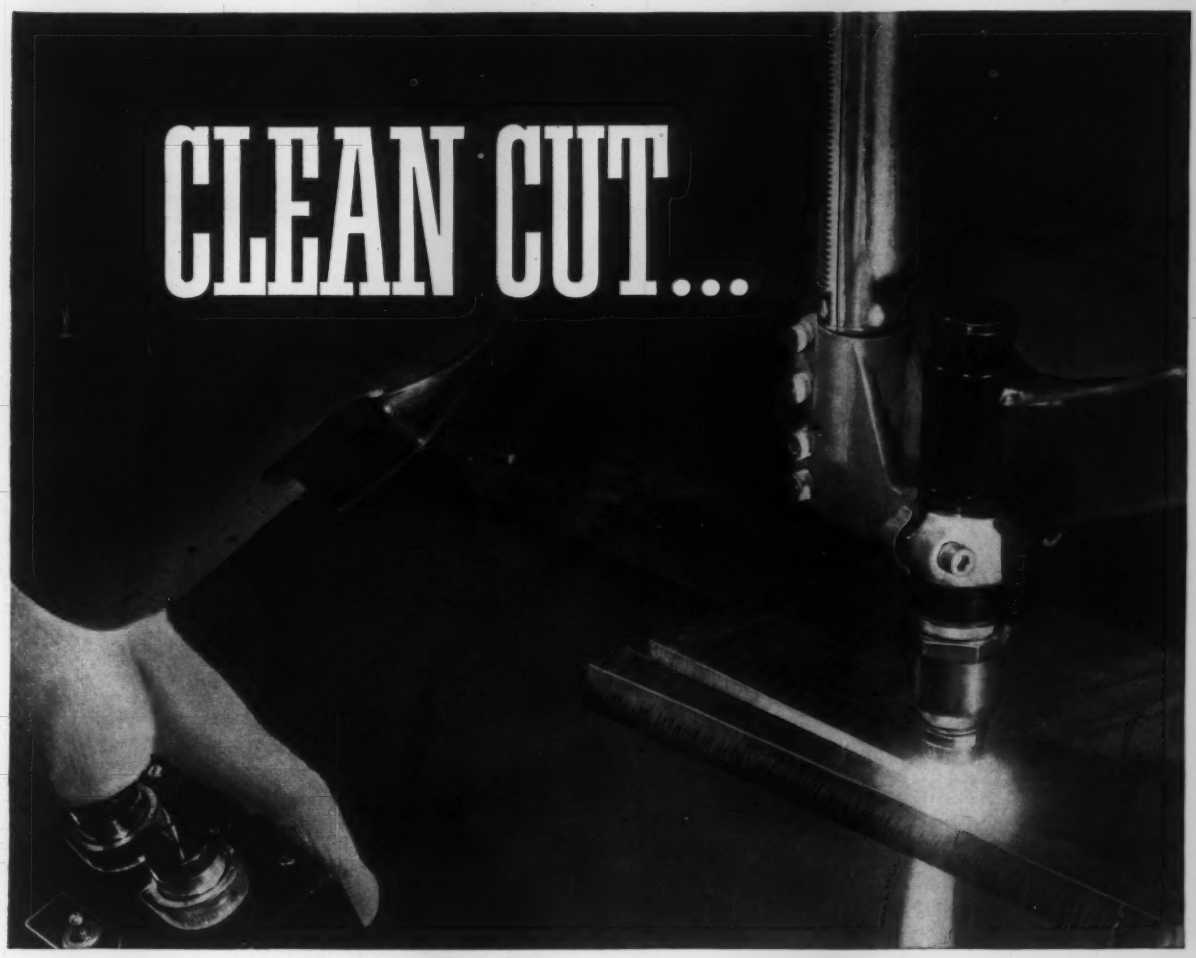
Listing of continuous direct current ampere-current ratings for 26, 33, 36, 40, 45, and 52-v RMS vacuum process selenium rectifier cells is contained in folder. Specifications for 20 cell sizes from 1 x 1 in. to 12 x 16 in. are given. 4 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 650 on Page 19

Universal Joints

Torque ratings, operating speeds, slip joint movement allowances, maximum operating angles, and physical and mounting dimensions for line of needle bearing universal joints are found in pages of Design Guide IJ320-1. They are used in agricultural, industrial, marine, and irrigation applications. 16 pages. Dana Corp., Standard Equipment Div., 253 Waggoner Blvd., Toledo 1, Ohio. G

Circle 651 on Page 19



. . . HELIARC Cutting turns hours to minutes

Before: It took 1½ hours to chip an 18-inch hole in an aluminum dome ⅝-inch thick. NOW—The hole is cut in *one minute*—with HELIARC Cutting.

Before: A 54-inch diameter dome hole in ⅝-inch rolled aluminum plate required about 5 hours, with chipping hammers. NOW—Manual HELIARC Cutting does it in about 4½ *minutes.*

HELIARC Cutting employs an extremely high-temperature, high-velocity arc that gives cutting speeds up to 1000 inches per minute on ¼-inch-thick material. It makes saw-like cuts, either square or beveled, in materials up to 3 inches thick . . . *and*, you can take the torch to the work. HELIARC Cutting is equally effective on aluminum, stainless steel, magnesium, copper, carbon steel, or cast iron.

See for yourself—ask your nearest LINDE representative to *prove* that HELIARC Cutting slashes time and labor costs over conventional methods. Call your local LINDE office today! Or write Dept. Q93, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde TRADE-MARK

UNION CARBIDE

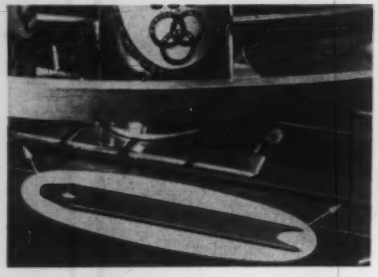
"Linde", "Heliarc", and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 500 on Page 19

NYLATRON® G S

Gives the property advantages of nylon, PLUS . . . improved mechanical characteristics:

- Greater Rigidity—higher modulus of elasticity, less deformation under load.
- Higher Heat Distortion Temperatures—distortion temperatures 70% higher than nylon 101.
- Lower Thermal Expansion—coefficient approximately 60% of nylon 101.
- Low Surface Friction—can be used without lubrication.
- High Wear and Abrasion Resistance —can outlast, outperform metal.



NYLATRON GS wear strips provide excellent wear cushion between metal bottling chain and conveyor stands. Due to inherent wear resistance and low surface friction, NYLATRON outwears metal strip while reducing wear on chain and stand.

NYLATRON GS, a molybdenum disulphide filled nylon*, is formulated to expand the field for nylon parts such as bearings, bushings, liners or other wear parts. Its superior mechanical and thermal characteristics coupled with the chemical and electrical properties of nylon result in a material with proven advantages. It is produced under controlled manufacturing standards to assure the ultimate in uniformity, quality and reliability.

Stock shapes of NYLATRON GS include rod, strip, tubing, tubular bar and plate in all standard sizes—for rapid, low-cost fabrication on standard metalworking tools. In addition, it is available in powder form for molding.

Polymer can also supply stock shapes of all commercial nylons on request.

Write today for detailed information about NYLATRON GS—or other nylon formulations to meet your specific requirements.

*Patents applied for

THE POLYMER CORPORATION OF PENNA.
Reading, Pennsylvania
Export: POLYPENCO, INC., Reading, Pa., U.S.A.

POLYPENCO

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW® and NYLATRON® GS †DU PONT TRADEMARK

HELPFUL LITERATURE

Coating & Molding Material

Chem-o-sol polyvinyl plastisol coating and molding compounds, detailed in Bulletin 144, can be used in a wide variety of products. Technical data on stock formulations and applications are given and case histories cite production cost-cutting techniques. 16 pages. Chemical Products Corp., King Philip Road, East Providence 14, R. I. B

Circle 652 on Page 19

Speed Reducers

Specifications of double reduction speed reducers with helical or herringbone gears are found in illustrated folder. Wide speed and horsepower ranges are offered. 4 pages. Alten Foundry & Machine Works, Inc., W. Wheeling Street, Lancaster, Ohio. G

Circle 653 on Page 19

Temperature Regulator

Temperature of liquids and air is automatically controlled by the No. 11 self-operating regulator, subject of illustrated Bulletin 329. Indicating and nonindicating types are offered. Specifications are presented in detail. 4 pages. Powers Regulator Co., Skokie, Ill. I

Circle 654 on Page 19

Gages & Valves

Liquid level gages and valves Catalog 335 illustrates standard and special function units and gives dimensional drawings, construction features, pressure-temperature graphs and ratings, and specifications. 8 pages. Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass. B

Circle 655 on Page 19

Agitator Drives

Use of the U.S. vertical Sychrogear gearmotor for agitator drives is covered in illustrated Folder F1957. Its construction features are presented and specifications are briefly covered. Ratings are 3-30 hp and 25-280 rpm. 4 pages. U. S. Electric Motors Inc., Box 2058, Los Angeles 54, Calif. L

Circle 656 on Page 19

Conveyor Pulleys

The Ful-Grip line of solid steel conveyor pulleys comprises both interchangeable bushing and fixed bore pulleys with face widths up to 148 in. Specifications and price information on the pulley line and on interchangeable bushings and belt conveyor take-ups are provided in Catalog CV-1. 4 pages. Maurey Mfg. Corp., 2915 S. Wabash Ave., Chicago 16, Ill. J

Circle 657 on Page 19

Power Circuit Breakers

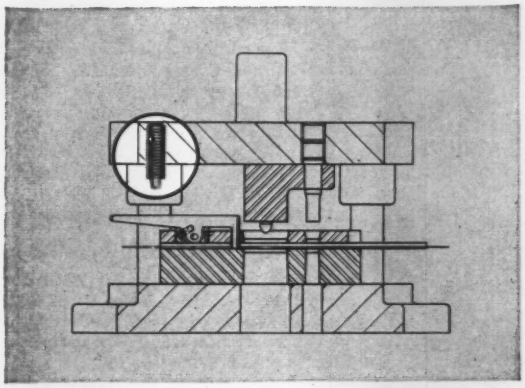
Operation and application of AK-2 low voltage power circuit breakers for circuits up to 600 v ac and 250 v dc are detailed in Bulletin GEA-5915. Units feature stored energy closing mechanism. Applications photos, system diagrams, dimensional drawings, rating tables, and guide form specs are provided. 20 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 658 on Page 19

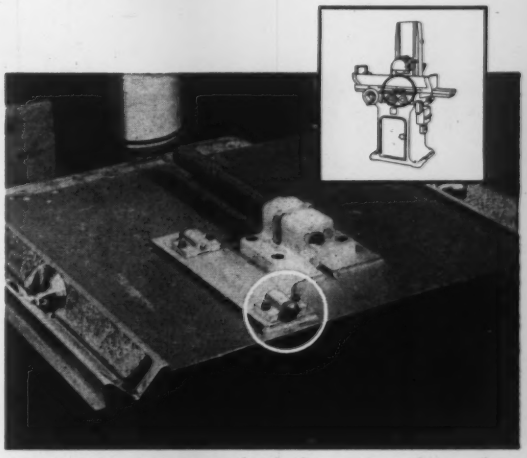
Practical Design Tips

Number 2 of a series.

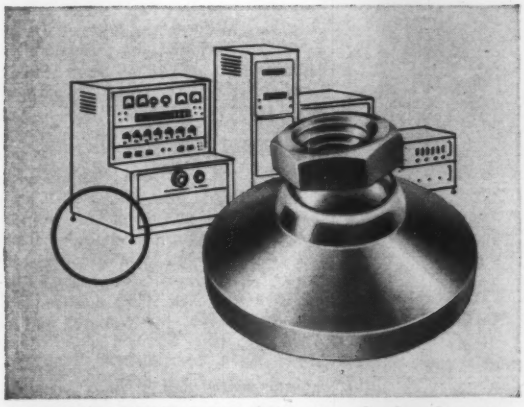
Substituting simple, off-the-shelf Vlier Tooling Accessories for complicated, custom-made devices in both tooling and original equipment applications can result in important savings. Why not put them to work in your plant?



TO STOP SMASHING DIE STOPS, substitute a Vlier Spring Plunger for the usual square-head screw. The plunger actuates the automatic stop perfectly and, unlike the screw, never needs adjusting no matter how many times the die is resharpened. Available in four models: 50 sizes.



TO CUSHION SHOCK as the bed traverses, this surface grinder manufacturer uses two Vlier Spring Stops, reducing wear and tear on the machine. These clever, spring-loaded devices, ordinarily used on fixtures where the absence of side walls prevents the use of spring plungers, are now available in three standard sizes: 3 end pressures. Special sizes made to quantity orders.



TO LEVEL MACHINE TOOLS, electronic racks, benches, etc., use the *standard* Vlier leveling pad. The pad swivels to 7½° each side of the center line; adjusts automatically to uneven surfaces. Unique ball-joint design distributes weight over entire pad surface.

TO GET NEW IDEAS on how to save with Vlier Tooling Accessories, send for new 28-page booklet "Typical Applications of Vlier Tooling Accessories." It suggests dozens of ways to use these time-savers in both tooling and original equipment applications. Write for your copy today.

New catalog now ready! Send for your copy today.

Insist on Vlier Tooling Accessories... there's still no substitute for quality!

VLIER ENGINEERING CORPORATION

8900 Santa Monica Blvd., Los Angeles 46, California
A Subsidiary of Barry Controls, Inc.

Circle 502 on Page 19

NEW CLUTCH

Stearns MODEL GS

Save — up to 41% on space
— up to 33% on installed cost

Here's a new concept in electro-magnetic clutches that add an even greater range of application to the already comprehensive Stearns line of over 100 standard clutch and clutch-brake combinations. Stearns can serve your needs on equipment ranging from business machines to ball mills — and larger . . . will also custom-design units to your specific requirements.

For complete data on the new "GS" line, call your local Stearns representative . . . or write for Bulletin 503F. 26

BRAKES MILWAUKEE Stearns WISCONSIN CLUTCHES

ELECTRIC CORPORATION
120 NORTH BROADWAY • MILWAUKEE 2, WISCONSIN

HELPFUL LITERATURE

Adjustable Voltage Drives

Three Supplementary Price Sheets give complete details on Class 8831 and 8832 motor-generator type adjustable speed drives for operation on 440-550-v 60-cycle ac. Sizes range from 3 to 200 hp, and speed changes range to 8:1. 2 pages each. Square D Co., 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 659 on Page 19

Port Fittings

Designed to replace conventional pipe thread and O-ring styles, line of straight-threaded port fittings affords all standard shapes. Design eliminates O-rings and assures leakproof metal-to-metal seal. Description is provided in Catalog M-57. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio. G

Circle 660 on Page 19

Iron & Steel Castings

Steel, pearlitic and alloy malleable, and electric gray iron castings produced to user's specifications are subject of Bulletin 17. Production facilities of companies and mechanical properties of cast iron and steels are covered. 4 pages. Belle City Malleable Iron Co., Racine Steel Castings Co., Racine, Wis. K

Circle 661 on Page 19

Titanium Fittings

Details on the types of AN and MS finished titanium fittings company makes are discussed in brochure. Fittings are used for high pressure/high temperature applications and replace stainless fittings at a 44 per cent weight savings. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif. L

Circle 662 on Page 19

Motorized Spindles

Catalog S-58 deals with motorized spindles rated from ½ to 10 hp with speeds of 900, 1800, and 3600 rpm. Also shown are belt driven spindles, feeds, slides, and a full line of accessories. 8 pages. Cincinnati Electrical Tool Co., 373 Mt. Hope Ave., Cincinnati 4, Ohio. G

Circle 663 on Page 19

Steel Belt Conveyors

Engineering Guide which enables the engineer to design and specify his own steel belt conveyor contains nomographs, tables, line drawings, and graphs which simplify calculation of dimensions, horsepower requirements, pulley diameters, and idler roller spacing. Text covers carbon and stainless steel belts. 8 pages. Sandvik Steel, Inc., Fair Lawn, N. J. D

Circle 664 on Page 19

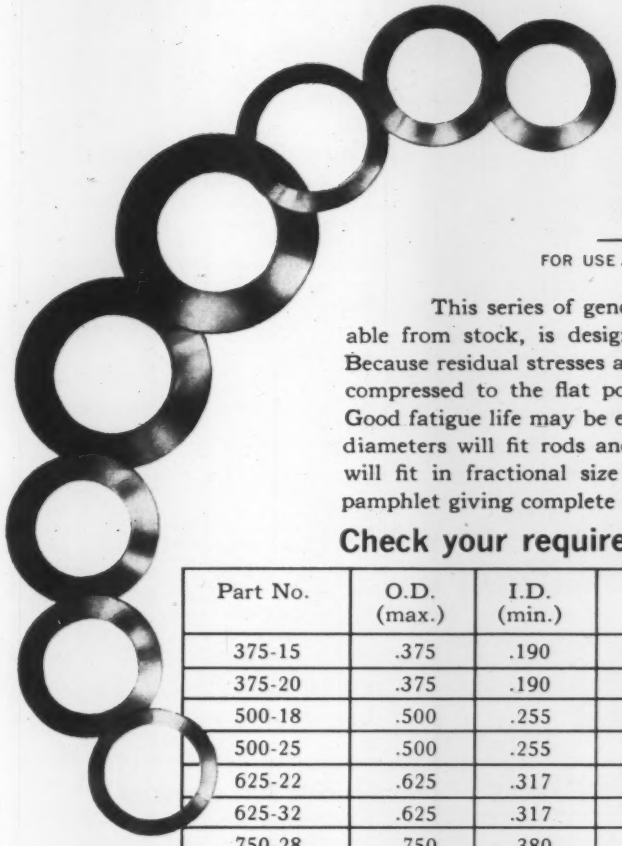
Fluid Power Components

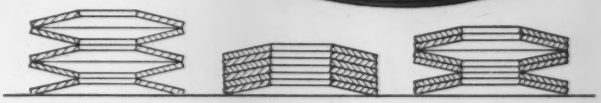
"Designers' Check List of Commercial Fluid Power Components" is title of Bulletin 100-P3 which pictures each type of component, describes features, and presents design tables. Data are for designers who use fluid power motors, pumps, valves, and cylinders. 4 pages. Commercial Shearing & Stamping Co., Youngstown 1, Ohio. G

Circle 665 on Page 19

Now... IN STOCK for prompt shipment

BELLEVILLE WASHERS



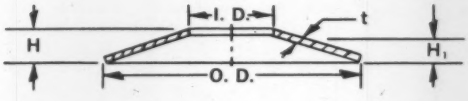


FOR USE.... IN SERIES ... IN PARALLEL .... IN PARALLEL-SERIES

This series of general-purpose belleville washers, all of which are available from stock, is designed primarily to carry high loads in limited space. Because residual stresses are introduced during manufacture the washers can be compressed to the flat position and released without loss of free cone height. Good fatigue life may be expected between slight preload and "H_1". The inside diameters will fit rods and bolts of fractional sizes and the outside diameters will fit in fractional size holes. Prices on request. Send for stock washer pamphlet giving complete information.

Check your requirements against these stock sizes

Part No.	O.D. (max.)	I.D. (min.)	t	H (approx.)	H_1	P_1 ±10%	P*
375-15	.375	.190	.015	.027	.021	35	55
375-20	.375	.190	.020	.030	.025	60	110
500-18	.500	.255	.018	.034	.026	45	70
500-25	.500	.255	.025	.038	.031	95	160
625-22	.625	.317	.022	.042	.032	70	105
625-32	.625	.317	.032	.048	.040	145	260
750-28	.750	.380	.028	.051	.039	110	175
750-40	.750	.380	.040	.059	.049	235	415
1000-35	1.000	.505	.035	.067	.051	175	260
1000-50	1.000	.505	.050	.075	.062	340	600
1250-40	1.250	.630	.040	.082	.061	230	330
1250-62	1.250	.630	.062	.092	.077	475	870
1500-45	1.500	.755	.045	.093	.069	284	400
1500-72	1.500	.755	.072	.107	.089	665	1180



*P Calculated Load at Flat Position

5840

Associated Spring Corporation

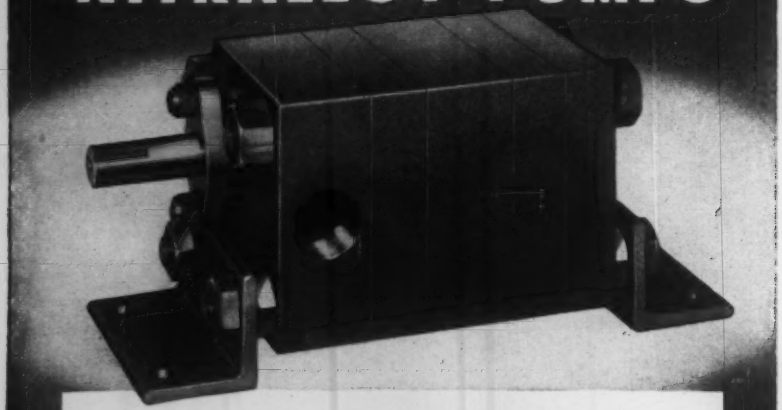
General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
F. N. Manross and Sons Division, Bristol, Conn.
San Francisco Sales Office, Saratoga, Calif.
Seaboard Pacific Division, Gardena, Calif.
Cleveland Sales Office, Cleveland, Ohio
Dunbar Brothers Division, Bristol, Conn
Wallace Barnes Steel Division, Bristol, Conn.

Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Circle 504 on Page 19

NORTHERN
NITRALLOY PUMPS



Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 PSI. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

NORTHERN ORDNANCE, INCORPORATED
Subsidiary
NORTHERN PUMP COMPANY
MINNEAPOLIS 21, MINN.

Circle 505 on Page 19

LOXSWITCH

—by the Hundreds!

FORD MOTOR COMPANY Bumper Plant!

Over 500 Denison LOXSWITCH Heavy Duty Limit Switches provide reliable switch control for Ford's new multi-million dollar bumper plant at Monroe, Michigan. LOXSWITCH Limit Switches last for millions of actuations under severe operating conditions. They feature the soundest electrical circuit, the longest mechanical life, plus low actuating force and 70° safety overtravel. All 13 models are water-, dust- and oil-tight at no extra cost! Switch to low-cost LOXSWITCH today.

FREE CATALOG 956 describes single pole-, double pole, multiple circuit and neutral position switches. Send for complimentary copy.

R. B. DENISON MFG. CO.
102 ST. CLAIR AVE., N. W. • CLEVELAND 13, OHIO

SPECIALIZING EXCLUSIVELY IN LIMIT SWITCHES

Circle 506 on Page 19

HELPFUL LITERATURE

High Frequency Equipment

Value of high frequency equipment as a means of increasing output or efficiency of high production equipment that is often limited by standard 60-cycle power is related in Bulletin 2250. Application and engineering data are given on two types induction frequency converters for 80 to 400 cps and motor-alterators or for operations requiring 400 to 3000 cps. 12 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 666 on Page 19

Electronic Cases & Boxes

Custom-built transit cases and sheet metal components for the electronics industry are described in illustrated catalog. Company facilities and typical products produced to user's requirements are shown. 12 pages. White Aircraft Corp., Palmer, Mass. B

Circle 667 on Page 19

Solenoids

Solenoids with pulls of 4½ and 9½ to 32 lb are detailed in Bulletin 4158. These alternating current units are available for operation on 110, 220, 440, and 550 v, 50 and 60 cycles. 4 pages. B/W Controller Corp., Birmingham, Mich. H

Circle 668 on Page 19

Fluid Power Circuits

Revised edition of "The Circuit Rider," a discussion of basic designs in fluid power circuits, shows circuits covering sequencing, semiautomatic and automatic cycling, dual pressure systems, safety systems, skip feed arrangements, and synchronization of two cylinders. 28 pages. Logansport Machine Co., Logansport, Ind. J

Circle 669 on Page 19

Finished Bore Sprockets

Bulletin 3 tabulates 99 sprocket sizes with 433 different bores in the line of finished bore sprockets. Units are stocked in single widths from ⅜ to 1 in. pitch. 4 pages. Acme Chain Corp., Holyoke, Mass. B

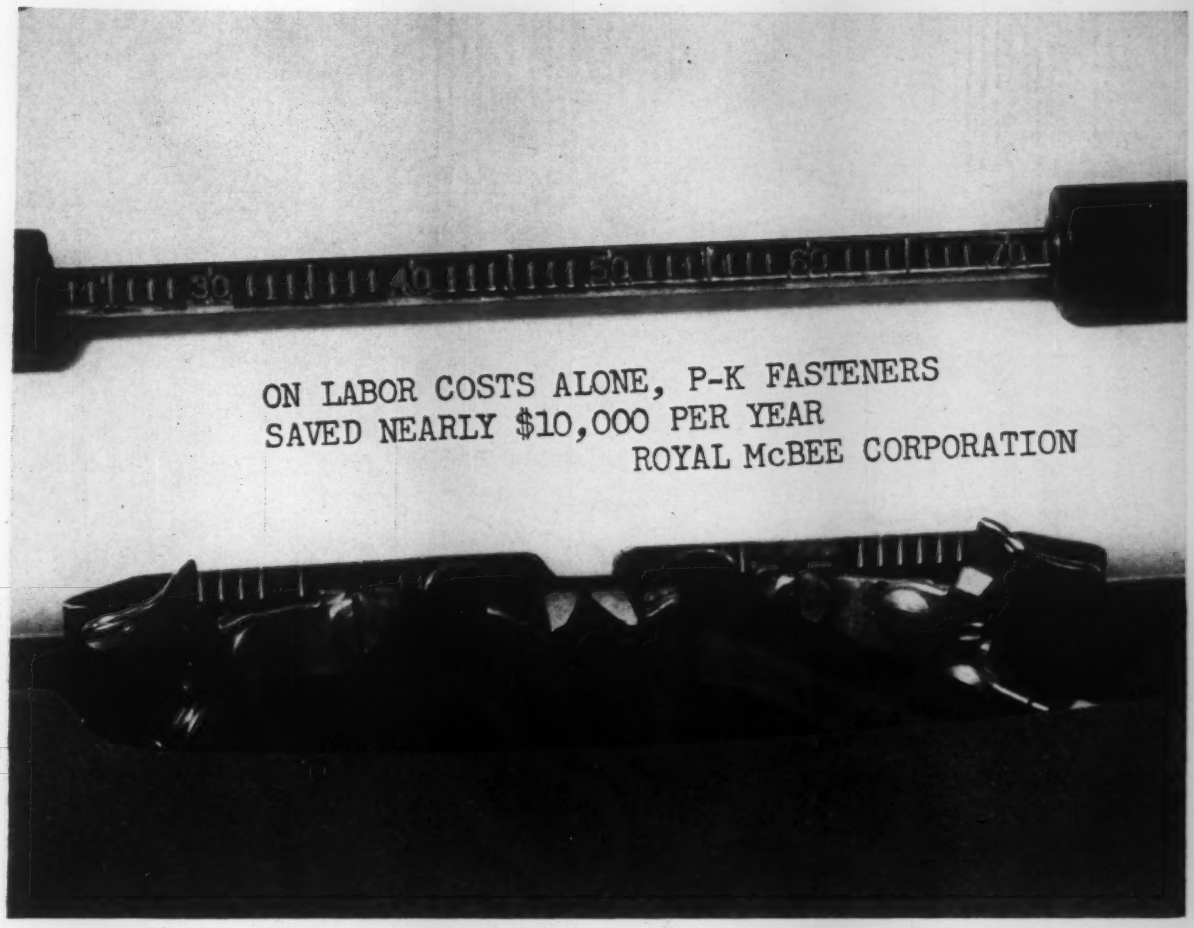
Circle 670 on Page 19

Forgings

Facilities for production of heavy precision forgings are listed and illustrated in Bulletin 586. Forging, heat treating, and finish machining equipment are covered. Typical forged products and forging weldments are shown. 12 pages. Request on company letterhead from Struthers Wells Corp., Titusville Forge Div., Titusville, Pa. N

Fastener Application

"Helpful Hints" is title of illustrated guide to the application of standard fasteners. Information is presented on selecting the right bolt, proper torque, bolt stresses, calculating proper bolt loading, tightening limitations, safety factors, threads, and protective coatings. One section is devoted to tapping screws. 16 pages. Write on company letterhead to Russell, Burdsall & Ward Bolt & Nut Co., 101 Midland Ave., Port Chester, N. Y. D



"For fastenings in steel, in plastics, and in die cast aluminum, we switched to P-K Self-tapping Screws and save time and money in every case," says Henry Teller, Supervisor of Assembly Standards, *Royal Typewriter plants of the Royal McBee Corporation.*

"At our Hartford plant alone, where more than 500,000 typewriters per year are assembled, we use P-K Self-tapping Screws for speedy, dependable fastening of Tenite plastic space bars, space bar stops and buffers, top covers and base masks, cover hinges and latches and many other assembly operations.

"Waste is ended, too. For example, just a bit too much pressure with air guns or the slightest angle when inserting ordinary screws, often caused stripping of the hole and a discarded space bar. Now, with P-K Screws, production is uninterrupted—rejections practically eliminated."

Royal McBee Corporation's experience with Parker-Kalon Self-tapping Screws is typical of literally thousands of similar cases. A P-K® Field Engineer will be glad to discuss your fastening applications—show you how you, too, can effect real savings.

PARKER-KALON® Self-tapping Screws

Sold everywhere through leading Industrial Supply Distributors

PARKER-KALON DIVISION, *General American Transportation Corporation, Clifton, New Jersey*

Circle 507 on Page 19

"Continue to use Morganite!"

TYPICAL TEST REPORT SHOWS MORGANITE OUTLASTS OTHER MOLD MATERIALS 7 TO 1!

No. 714A

"During the past 12 months, 1050 regular molds were used on the large jobs at considerable cost. These molds had an average life of 2½ hrs. on the machines for a total of 2625 hours. In the same number of hours, only 175 Morganite molds (average life 15 hours) are needed at a fraction of the cost. Substantial savings in less down time also realized. Due to mold changes, when using Morganite, another savings would be realized by saving ware now lost during such changes.

Morganite ordered for use on all future runs."

Signed (Name on request)
Chief Test Engineer

CAM THRUST BEARING

SELF LUBRICATING PISTON RING

JET ENGINE PUMP VANE

MORGANITE CURRENT COLLECTOR

Bearings
Pump Vanes
Valves
Slides
Seal Noses
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Rod Packings
Piston Rings
Electro-Mechanical Contacts

Specify SELF-LUBRICATING MORGANITE

Production engineers and product designers! Morganite offers many important advantages ... is self-lubricating, non-contaminating, corrosion resistant, non-warping, and non-gumming. Get all the facts on cost-saving, high-performance Morganite components now.

Call or write for complete information—no obligation.

Morganite INCORPORATED ... FOR OVER HALF A CENTURY

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Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts.
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

HELPFUL LITERATURE

Electronic Computers

Described in Manual U1518 is the new Flow-Matic system which makes it possible to communicate with computers in the English language instead of with mathematical symbols. It enables businessmen and designers to break through the symbol barrier and obtain fast, accurate programing; simple programing analysis; and better checking of systems design. 115 pages. Write on company letterhead to Sperry Rand Corp., Remington Rand Div., 315 Fourth Ave., New York 10, N. Y. D

Rotary Actuators

Aircraft rotary actuators, made up into any of 40 different packages from 12 standard components, are the subject of Bulletin MR-58. They provide a choice of load ratings to 100 lb-in. and speeds ranging from 0.5 to 50 rpm. Either 26-v dc or 115-v 400-cycle ac units are offered with strokes from 20 to 270 degrees. 4 pages. Write on company letterhead to Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J. D

Relays

Quick, easy reference to a complete line of telephone type relays and rotary stepping switches is afforded by catalog entitled, "Relays and Switches for Industrial Control." More than 200 drawings, diagrams, circuits, and charts are used. 100 pages. Write on company letterhead to Automatic Electric Sales Corp., Northlake, Ill. J

Large Coil Springs

Mathematical charts and data to aid buyers and users of coil springs in designing and selecting the right heavy duty type to meet specific needs are contained in illustrated handbook. It also reviews company's facilities and describes fatigue-resistant single heat treated, shot peened helical springs. 48 pages. Write on company letterhead to Crucible Steel Co. of America, Spring Div., Box 2518, Pittsburgh 30, Pa. F

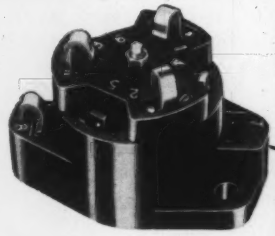
Optical Gaging

"Optical Projection—the key to improved gaging technique" is title of Catalog No. 10. It covers chart layout methods, standard chart-gages, micro-gage chart-gages, standard accessories, projector tracers, custom chart-gages and fixtures, and contour transcribers. Simple, nontechnical language is used to explain optical gaging practices. 114 pages. Write on company letterhead to Optical Gaging Products, Inc., 26 Forbes St., Rochester 11, N. Y. N

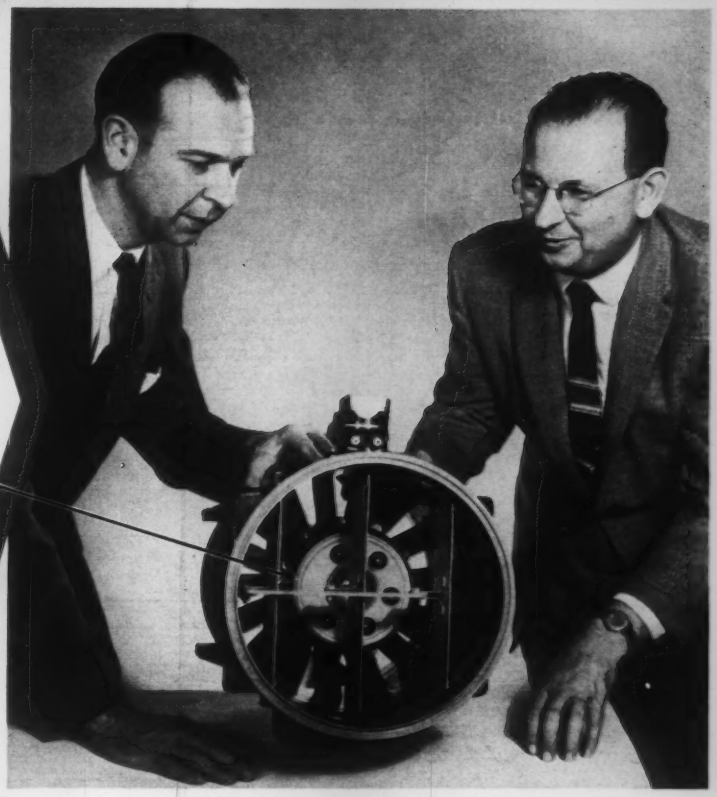
Electrical Connectors

Complete specifications, outline drawings, and other design and application data on Series 20 miniature electrical connectors are contained in revised Catalog 20-458. Types for practically every need are described. 40 pages. Write on company letterhead to DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

KLIXON
3-PHASE AIRCRAFT MOTOR PROTECTORS



Guard Against Overtemperature in AiResearch Condenser Fan



Roy Schinnerer, left, Senior Project Engineer, and Elvin Lytle, Design Specialist, examine the AiResearch Condenser Fan used on the Boeing 707.

AiResearch Manufacturing Division of the Garrett Corporation, long a leading manufacturer of electro-mechanical components and air conditioning systems for aircraft, is a major user of KLIXON Inherent Overheat Motor Protectors.

Elvin Lytle, Design Specialist of AiResearch, selected a 3-phase KLIXON Motor Protector for use in this 10 HP electric motor driven condenser fan, a component of the vapor cycle air conditioning system on the Boeing 707 Jet Stratoliners ordered by American Airlines. In this application, the KLIXON Protector shuts off the fan motor if excessive inlet air temperature or inadequate air flow causes the motor windings to overheat.

METALS & CONTROLS CORPORATION
Spencer Division
3209 Forest Street, Attleboro, Mass.

KLIXON®

Circle 509 on Page 19

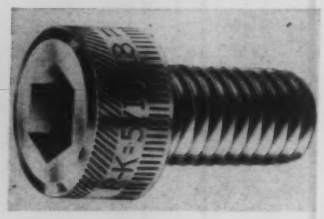
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Cap Screw

eliminates indentation under high tensile load

Pre-Lode socket-head cap screw has more wrenching area and an enlarged bearing surface. It eliminates indentation while utilizing and maintaining full holding power under high tensile load. With increased bearing area under the head, fastener distributes load uni-



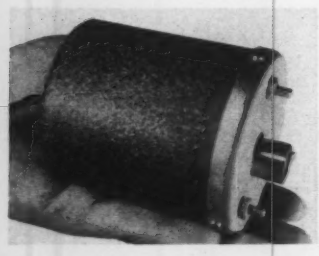
formly, prevents sapping of tightening force used in preloading, functions in holes with greater body clearance, and has long working life. Screw is available in all standard sizes from $\frac{1}{4}$ to 1 in. All are size-marked, and many sizes have enlarged sockets to permit greater wrenching area. **Parker-Kalon Div., General American Transportation Co.,** Clifton, N. J. D

Circle 671 on Page 19

Gear Motor

shaft-mounted unit has torque rating of 75 lb-in.

SM-5 Shaftrol is a control gear motor which mounts directly on driven shaft to replace handwheels, cranks, or levers. Unit is available with or without built-in potentiometer to provide remote or automatic control of valves, adjustable-speed drives, variable-displacement pumps, and positioning screws. Motor is available with gear reduction of two to four stages with ratios from 80:1 to 1600:1. Precision hobbed and hardened gears provide continuous-duty torque rating of



75 lb-in. Unit operates on 110-v, single-phase power. **Jordan Co.,** 3235 W. Hampton Ave., Milwaukee, Wis. K

Circle 672 on Page 19

Epoxy Material

for use at high temperatures

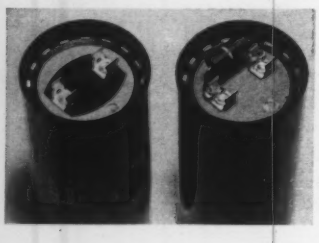
Hysol 6000HH-867, available in sheet, rod, and tube form, is an epoxy material recommended for coil forms, resistor bobbins, resistor shells, and other intricate parts used at elevated temperatures. It can be readily machined, providing excellent workability. Available in black filled form only, material has heat-distortion point higher than 150 C. It meets requirements of MIL-16923B for flame resistance and moisture absorption. **Houghton Laboratories Inc.,** Olean, N. Y. N

Circle 673 on Page 19

AC Capacitors

incorporate printed resistors for charge bleed-off

New ac capacitors incorporate printed resistors which automatically



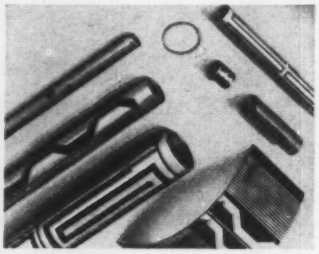
bleed voltage out of capacitor when circuit is turned to off position. This prevents point burn-outs in relays and provides for safer servicing by eliminating charge normally left in capacitor. Printed-resistor ac capacitors (left) were designed for air-conditioner use, providing faster and more economical assembly and servicing operations. Capacitors with printed resistors are available in following electrical values: 15,000 ohm, 2 w, − 30 per cent on 1-13/16 and 1-7/16 in. diam covers; and 20,000 ohm, 4 w, − 30 per cent on 2-1/16 and 2-9/16 in. diam covers. **Application Engineering Dept., Aerovox Corp.,** 740 Belleville Ave., New Bedford, Mass. B

Circle 674 on Page 19

Tubular Circuits

are applied to tubes with ID down to 0.020 in.

Solderable silver circuits are directly printed on exterior, interior, or both surfaces of tubes having an ID as small as 0.020 in. Cir-



cuits can be applied to almost any type of nonconducting tubular material including Teflon, Kel-F, epoxy, phenolic, polyester, silicone, glass, ceramic, and thermoplastics. Conductive inks are deposited from 0.0004 to 0.0015 in. thick, depending upon requirements. Pattern tolerance can be held, under some circumstances, to ± 0.001 in. Circuits are stable to 500 F. Direct-printed tubes are used as instru-

Holding parts in place is a snap with quality EATON-RELIANCE rings

For faster, more secure assembly of your products —with savings that will help you hold the line against rising costs—use quality snap, bearing, lock and retainer rings by Eaton-Reliance. You'll cut the cost of fabricating the parts of your product, too, because these versatile rings of a million uses reduce machining costs and simplify the design of individual parts. You can use Eaton-Reliance Rings as heat-treated shoulders on shafts and in counterbores to support bearings and other parts—with substantial savings in machining time, dead metal and final assembly.

Eaton-Reliance Rings, manufactured on precision machines, are made of spring-quality steel, cold drawn in our own plant, and heat treated for the right measure of tension. End cuts and cross-sections are made to your exact requirements. From start to finish, we control every detail to assure you the highest quality rings which can literally hold your products together.

Without obligation to you an Eaton-Reliance fastener engineer will gladly study your product to show you how these versatile rings can cut its cost. Write for the name of the nearest representative, or send for Engineering Bulletin No. 55.

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RELIANCE DIVISION
MANUFACTURING COMPANY
506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Motor Truck Axles • Permanent Mold Gray Iron Castings • Forgings • Heater-Defroster Units • Automotive Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Gears • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

Circle 510 on Page 19

Experience—*the extra alloy in* ***Allegheny Stainless***

key words in solving production puzzles:

Allegheny for Stainless; Ryerson for Service

If one of your toughest production puzzles is getting top quality stainless steel *when* you need it, check in now with the Allegheny-Ryerson combination.

Allegheny Ludlum is the leading producer of stainless steels in all forms. And Ryerson, long recognized as the largest and best steel service center, carries Allegheny Stainless. This unbeatable team brings you the best quality stainless quick, when you need it.

Ryerson now stocks 2,351 shapes, sizes, finishes and alloys of Allegheny Stainless . . . the most complete line of stainless anywhere! And Ryerson relieves you of the inventory cost, gives you as quick service as your own stockroom.

Whether your order is for Allegheny Stainless sheet, plates, bars or whatever, Ryerson stocks it. Trained salesmen and technicians to help in selecting or in fabricating are at your service.

Call Ryerson, for top quality Allegheny Stainless from warehouse stocks. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.***

WSW 7124

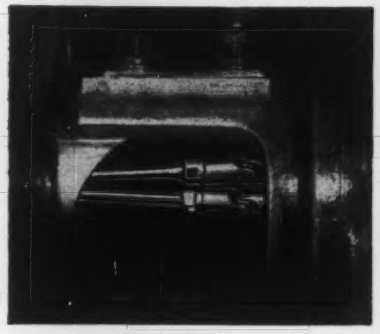
ALLEGHENY LUDLUM

for warehouse delivery of Allegheny Stainless, call RYERSON

Export distribution: AIRCO INTERNATIONAL

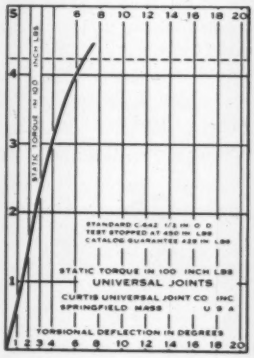
EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC
SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

Torque Curve ½" Curtis Universal Joint

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 512 on Page 19

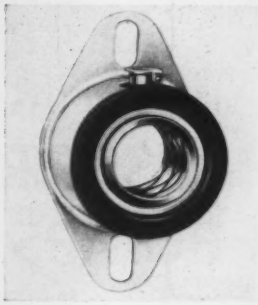
ment housings, for faraday shields, capacitance-type fuel gages, resistors, heaters, probes, commutators, and microwave parts. **J. Frank Motson Co.**, Flourtown, Pa. E

Circle 675 on Page 19

Sleeve Bearing

for flanged or side mounting

New two-bolt sleeve bearing is interchangeable with most two and four-bolt units. Designed for flange or side mounting, bearing has graphited or sintered-bronze bushing, both self-lubricating. Available for six standard shaft sizes from ½ through 1 in., bearing is for



general use where severe stress conditions do not prevail. Bolt size requirement is 5/16 in. One-piece housing is 16-gage steel with corrosion-resistant cadmium finish. Rubber liner isolates bearing and assures constant, controlled self-alignment, high vibration absorption, and quiet operation. **Randall Graphite Bearings Inc.**, Greenlawn & Lake Streets, Lima, Ohio. G

Circle 676 on Page 19

Lightweight Bellows

have controlled wall thickness

New bellows, machined from aluminum alloys, are available for use with liquid oxygen, fuels, and in other critical applications where light weight is required. Where high-temperature applications are involved, bellows of Inconel-X, A-286, and other high-temperature and high-strength alloys are available. Thickness or strength can be concentrated where stress is highest, eliminating failure due to fatigue. Bellows with rated pressures of over 3000 psi are made in sizes

Circle 513 on Page 19→

NOW, in G-E Form G motors

NEW EXTRA VALUE FEATURES

See the next 10 pages for details

OPERATION up turn GENERAL ELECTRIC

Buy Now for Extra Value

GENERAL ELECTRIC

"Choose from this wide range of Gast Air Compressors", says C. E. Bradley, Ass't. Sales Mgr. "Vacuum Pumps are also available in corresponding models."

Here's high performance . . . in a full line of

GAST rotary vane COMPRESSORS and VACUUM PUMPS

When you select original equipment Air Pumps, look at the Gast Line. You'll see how your product—and budget—may benefit.

Within a well-defined range, Gast Pumps excel on hundreds of product applications. (Capacities .6 to 45 cfm.; pressures to 30 psi., vacuum to 28 in. Hg.) Precision-built primarily for O.E.M. use, they are rugged and dependable. Simple rotary-vane design maintains like-new performance for years, because vanes take up their own wear automatically. Air displacement is positive and pulseless—no air tank needed. Ball bearings and self-adjusting shaft seals keep efficiency high.

Types include: Dual-chamber (one chamber for vacuum, one for pressure), integral-motor pumps, light-duty models for moderate pressure or vacuum, and fan-cooled models for heavy-duty service. Oil-less (carbon-vane) types provide absolutely oil-free air if desired.

Submit your problem for suggestions by Gast Engineers—or . . .

Write today for Catalog on Compressors or Vacuum Pumps. State specific type or capacity that interests you.

(1) *(Front to rear) Dual Chamber Pumps:*	(2) *Integral-Motor Pumps for O.E.M. or Lab use:*	(3) *Light-Duty Models Moderate Vac./Press.*	(4) *Heavy-Duty Models, with Fan Cooling, V-belt or Direct Dr.*
Model 11 x 1740, total to 23 cfm.	0521, 1/3 hp. to 3.8 cfm.	3040, up to 24.2 cfm.	2565, to 21.0 cfm.
10 x 1040, to 18 cfm.	0321, 1/4 hp. to 2.2 cfm.	1550, up to 15.0 cfm.	1065, to 8.3 cfm.
Single (In Hand) AD-440, to .6 cfm.	0211, 1/6 hp. to 1.3 cfm.	0740, up to 5.6 cfm.	0465, to 4.0 cfm.
	0406, 1/12 hp. to .6 cfm.	0440, up to 4.0 cfm.	4565, to 45.0 cfm.
		0240, up to 2.0 cfm.	

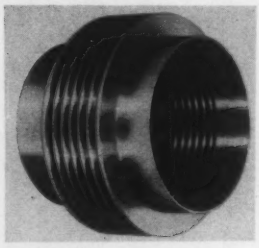
GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"



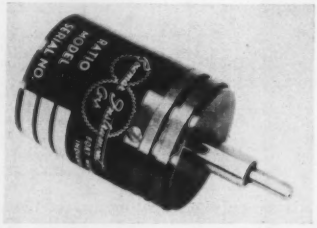
from 1/4 to more than 60 in. in diam. **Hydrodyne Corp.**, 7350 Coldwater Canyon, North Hollywood, Calif. L

Circle 677 on Page 19

Speed Reducer

has 30-min maximum backlash

Concentric shaft speed reducer, designated X-530, is a single-ended unit built with high-speed input shaft coaxial with a low-speed output sleeve. Input shaft extends about 3/8 in. to receive driving power. Reducer, which is available in most ratios, provides space and weight advantages. Driving sources, potentiometers, cams, switches, and speed reducer can all be mounted on same base plate. Greater inherent rigidity is provided with single mounting plate construction.



Unit has maximum backlash of 30 min, with 3 oz-in. reversing load. Frame diameter is 1.062 in. Unit shown is equipped with a slip clutch to protect pot stops. **Bowmar Instrument Corp.**, 8009 Bluffton Rd., Ft. Wayne, Ind. J

Circle 678 on Page 19

Retaining Rings

are crescent-type units for shafts from 1/8 to 2-in. diam

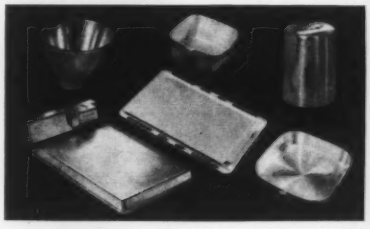
Series 2000 crescent-type retaining rings provide shoulders on grooved shafts to position pins, shafts, bearings, bushings, gears, and other components. Radially applied, the rings are particularly suited to ap-

make it BETTER within your BUDGET

Many cost-saving advantages are often overlooked on straight competitive bidding. Your engineering design, plus expert foundry analysis, can result in quality production castings at lower end-cost.

Monarch's proven techniques and automated production experience help your own engineering staff to improve initial design. Monarch offers to you, years of pioneering experience in

ALUMINUM PERMANENT MOLD
ALUMINUM DIECASTING and
CERTIFIED ZINC DIECASTING



In addition you gain Monarch know-how and unique facilities to produce finished castings that reduce end-cost.

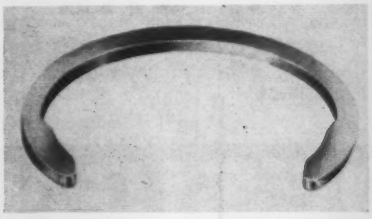
Exclusive Velvaglaze® and Porceglaze finishes are examples of progressive research and customer service. Send your next inquiry to Monarch.

MANUFACTURING ACHIEVEMENTS in MOLTEN ALUMINUM

MONARCH ALUMINUM MFG. COMPANY
9205 Detroit Avenue Cleveland 2, Ohio

Circle 515 on Page 19

plications which do not require a large shoulder, where space is limited, or where axial access is difficult or impossible. Easily snapped into position, they resist considerable thrust and vibration without displacement, and can be removed and reused without special tools and without loss of resiliency. Rings are available in 25 sizes to fit shafts from 1/8 to 2 in., in carbon spring steel, stainless steel, phosphor bronze, and beryllium copper. Available finishes include oil-dip,



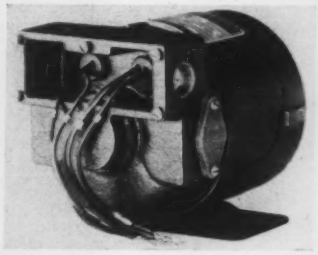
black oxide, Parkolac-black, nickel plating, and cadmium or zinc plating in bright, dichromate dip, plain, or olive-drab iridite dip. **Industrial Retaining Ring Co.**, Dept. PB-17, 57 Cordier St., Irvington 11, N. J. D

Circle 679 on Page 19

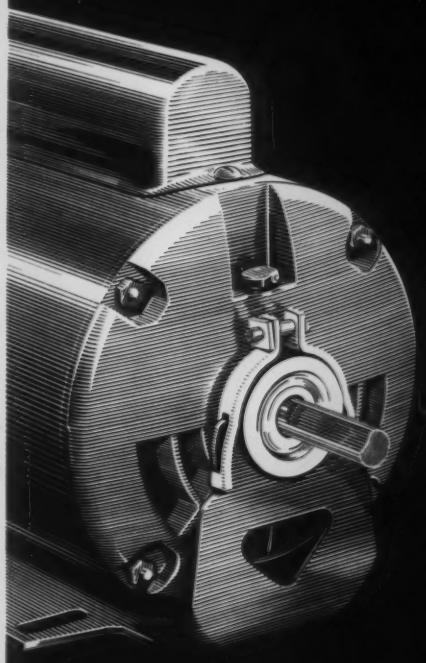
DC Motor

42-frame unit has cast-in terminal box

New cast-in terminal box that facilitates installation wiring has been added to NEMA 42-frame, fractional-horsepower dc motor used for general-purpose constant or adjustable-speed applications. Terminal box is furnished with a steel cover plate which seals connections against dirt and moisture. The 4 5/8-in. diam motor, available in ratings to 1/12 hp, gives constant torque by armature control over entire speed range and provides increased speeds up to 50 per cent over base speed by field control. Designated BC 26, the new motor is of cast-iron construction and has a large internal fan pressed



G-E fhp motor New Extra Value 1

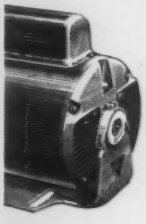


PROTECTIVE FINISH

Rust-resistant shaft and hardware stop corrosion, simplify maintenance

The special gun-metal-like shaft treatment makes servicing easier because fans, pulleys, and couplings can't rust on. End shield latches and hardware are bright plated to last longer and look better. Because maintenance is simplified on today's Form G motor you get added saleability, extra customer satisfaction. Investigate this extra value feature.

702-78



BUY NOW FOR EXTRA VALUES

OPERATION up turn GENERAL ELECTRIC

GENERAL ELECTRIC

Circle 513 on Page 19

MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS

Challenging job opportunity on the editorial staff of

MACHINE DESIGN

Here's your chance to break in on a growing field where aggressive creative work is really appreciated. MACHINE DESIGN has a staff opening for an engineer with an interest in both engineering and editorial work. This job provides stimulating contact with many engineering areas plus opportunity to grow and progress as a specialist in a particular branch of design engineering.

Some evidence of design engineering experience is necessary, and an ME or EE degree would be desirable. Writing ability and interest are also required, although a heavy background of editing or writing is not essential.

Salary will depend on experience; progress for the right man can be rapid. Headquarters are in Cleveland with opportunities for travel to attend engineering meetings and expositions.

If you are interested, send full details of your engineering background to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

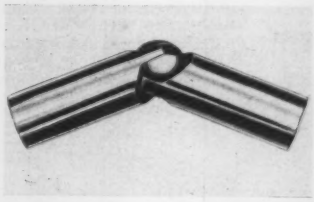
on armature shaft for effective ventilating action. Ball bearings and brush mechanisms are rubber mounted for long life and reduced maintenance. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 680 on Page 19

Universal Joint

has 20-deg maximum angle of operation

Simplex 3/16-in. OD universal joint has static torque rating of 250 oz-in. Forks are nonmagnetic stainless steel, and ball is bronze. Originally developed for electronic instrumentation, unit also has application in many other fields. Joint has overall length of 1 in. and



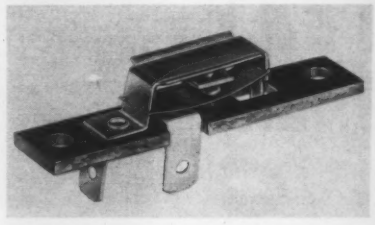
maximum angle of operation of 20 deg. It is available with standard bore 3/32 x 5/16 in. deep, and also solid and oversize for special applications. **Curtis Universal Joint Co. Inc.**, 4 Birnie Ave., Springfield 7, Mass. B

Circle 681 on Page 19

Snap-Action Switch

has low, flat actuator

No. S75-00A switch has a low, flat actuator suited for pushbutton, cam, or interlock applications on adding machines, vending machines, remote television controls, phonographs, and radio controls. Built-in positive stop limits overtravel and prevents damage to switch mechanism. Over-center bowed blade provides high contact pressures and fast contact transfer with long life expectancy. Variations of operating point and operat-



HYDRAULIC EQUIPMENT WORKS BETTER with FERROFILTER

Magnetic Separators on the job

Low Pressure FERROFILTERS

1" and under made this way
Other low pressure models to 3" pipe sizes
High Pressure Models Also Available

NO MORE RUST AND SCALE

with FERROFILTERS in fluid power systems. These magnetic separators keep ferrous particles from circulating and building up . . . help prevent scoring, scratching, sticking and non-functioning of valves, pumps and other precision parts which are sensitive to fine particles of metal and rust.

Write for more complete information contained in our

BULLETIN PM-83

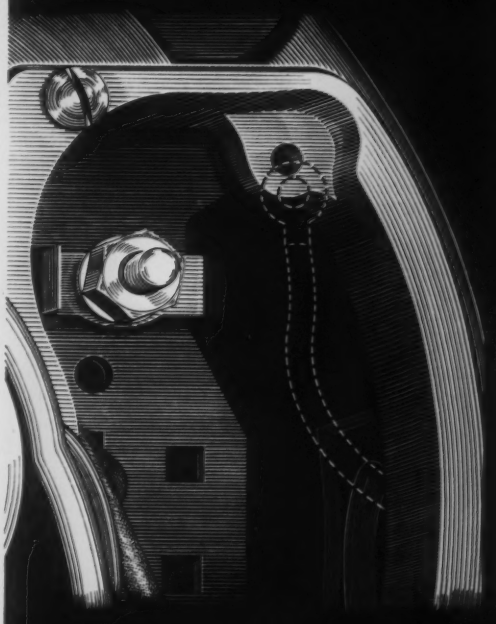
S. G. FRANTZ CO., Inc.

Brunswick Pike and Kline Ave.

P. O. Box 1138 Trenton 6, N. J.

Circle 517 on Page 19

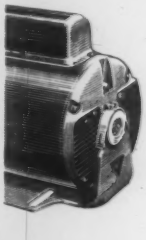
G-E fhp motor New Extra Value 2



SAFER OPERATION

Built-in grounding lug permits fast, easy grounding to meet UL standards

Now on Form G motors you get a built-in grounding lug that meets UL standards for grounded third lead when required.



With a self-tapping screw you can make ground connections quickly, easily and inexpensively. This feature assures safe, permanent grounds. There's no chance of disconnection during maintenance. Ask about this extra value.

702-79

BUY NOW FOR EXTRA VALUES

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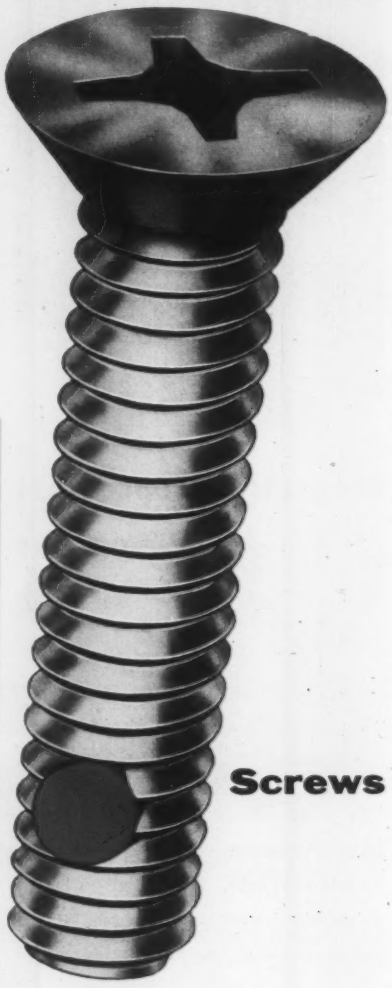
Circle 513 on Page 19

Continental has the cure for vibration "headaches"

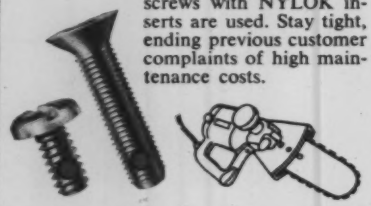
the one-piece locking screw that won't work loose



HOLTITE® NYLOK Screws and Bolts are one of the many progressive ideas in fasteners pioneered by Continental. These one-piece, self-locking fasteners with the Nylon insert eliminate the need for lock washers, jam nuts, wiring, and similar devices. If you have fastening problems (like the applications below), for which Nylok is the practical solution, you can start now to save assembly dollars, and give your product a definite competitive advantage.

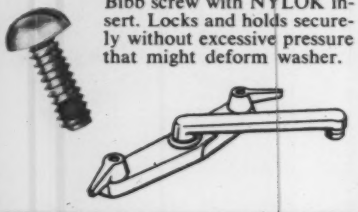
BEAT VIBRATION, KEEP CHAIN SAWS "ON THE JOB"

Several styles of machine screws with NYLOK inserts are used. Stay tight, ending previous customer complaints of high maintenance costs.



HOLD FAUCET WASHERS FIRMLY AT CORRECT ADJUSTMENT

Slotted round head Monel Bibb screw with NYLOK insert. Locks and holds securely without excessive pressure that might deform washer.



HOLTITE® NYLOK® Self-locking Screws

STAY TIGHT UNDER CONSTANT STRESSES IN METAL CHAIRS

Oval head machine screw with NYLOK insert, used in telephone operators' chairs, solved problems of excessive maintenance, clothing damage, etc.

WITHSTAND REPEATED SHOCKS IN VISE JAW INSERTS

Phillips fillister head machine screw with NYLOK insert will not back out under heavy strains of vise jaw clamping.

HERE'S WHY HOLTITE NYLOK® LOCKS SECURELY

Resilient nylon plug (A) sets up a lateral thrust, smoothly wedges mating threads together (B). All locking action is on threads: head is not stressed. Locking is positive . . . seated or unseated.

One piece — no separate parts
Can be removed and replaced
Interchangeable — reusable
Locks seated or unseated
Acts as seal for gases, liquids

CHECK YOUR ASSEMBLIES. Find out where Continental cost-saving ideas, like Nylok, can cut your assembly costs. Continental Assembly Specialists are fully qualified to analyze your operations and advise which fasteners — *standard or special* — can save you most. For prompt service, write or phone: Continental Screw Co., 461 Mt. Pleasant Street, New Bedford, Mass.

CONTINENTAL

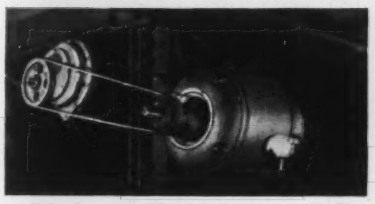
SCREW COMPANY, NEW BEDFORD, MASS.

HOLTITE FASTENERS

HY-PRO TOOL COMPANY... DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY

Circle 518 on Page 19

Shaft Mounted GEAR REDUCER



- **Eliminates Motor Bases...Rails ...Supporting Structures... Shaft Couplings**
- **Ends Alignment Problems**

Provides a compact, space saving power transmission unit for countless industrial applications. Easily installed direct to driven shaft. Mounts vertically or at any angle. Affords infinite speed ratios through use of variable speed pulleys or by changing sheaves, sprockets or prime mover speed. Simple adjustment of rod and turnbuckle maintains proper belt tension.

18 models:

Single reduction types . . . 98% efficient . . . 4.5:1 nominal speed ratio.

Double reduction types . . . 96% efficient . . . 14.7:1 nominal speed ratio.

Horsepowers: fractional to 120.

Output speeds: 8 to 425 rpm.

Hollow shaft sizes: $1\frac{7}{16}$" to $5\frac{15}{16}$" (maximum) . . . bushings available to accommodate smaller shafts.

Roller backstop: available where protection against reversal of direction is required.

Torque reaction bracket: furnished for units with platform-mounted or reversing drives.

Request Catalog R-58 for complete information. Give application data for specific recommendation.

LOVEJOY FLEXIBLE COUPLING CO.

4818 W. LAKE ST. • CHICAGO 44, ILL.

Circle 519 on Page 19

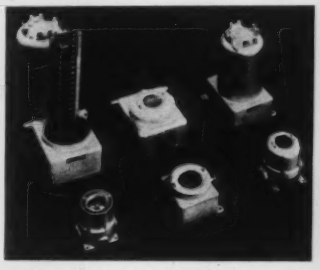
ing force can be obtained by changing point of operation on actuator. Panel measures $2\frac{1}{4}$ in. long and $\frac{1}{2}$ in. wide; switch mechanism extends $\frac{3}{8}$ in. above panel base. Switch is rated 10 amp, 125 v ac, 5 amp, 250 v ac, and 1/3 hp, 125-250 v ac. **Cherry Electrical Products Corp.**, 1650 Deerfield Rd., Highland Park, Ill. I

Circle 682 on Page 19

Timing Controls

are explosionproof units

New explosionproof timing controls include single and multiple-cam timers with 1 to 19 switches. Individual switch rating is 10 amp, and time cycles range from 2/3 sec to 72 hr. Units meet requirements of



National Electric Code (Article 500) for use in hazardous atmospheres of Class 1, groups C and D, and Class 2, groups E, F, and G; they also meet specifications of NEMA No. 7. **Industrial Timer Corp.**, Dept. OXO, 1407 McCarter Highway, Newark 4, N. J. D

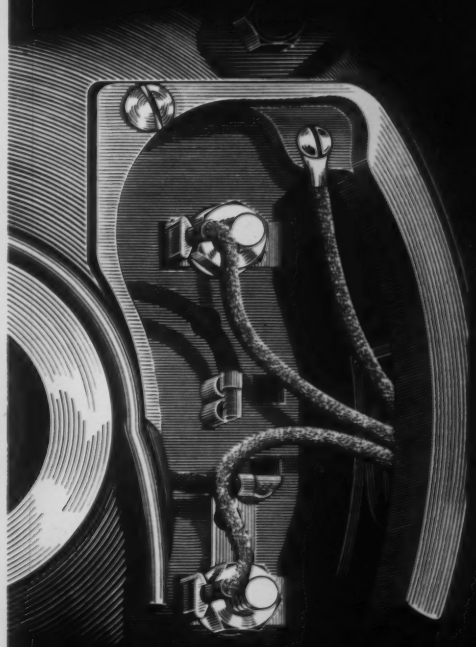
Circle 683 on Page 19

Roller Bearing

is combination thrust and radial unit

New cylindrical roller bearing is designed for applications where both thrust and radial loads must be carried in a restricted space. Unit consists of radial and thrust roller assemblies, with flanged inner race of radial section serving also as revolving plate of thrust section. Outer race of radial bearing is stationary with respect to inner race, and is completely separable to facilitate assembly in restricted space. Radial portion of bearing is located on shaft. Bearing, designed for both continuous and intermittent operation, is available with bronze or Rollube retainer. Cyl-

G-E fhp motor New Extra Value **3**

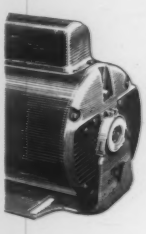


EASIER WIRING

This enlarged wiring compartment saves hook-up time on the assembly line

Wiring compartments on G-E motors are now roomier and easier to work with. An enlarged opening allows greater accessibility. A narrower terminal board makes it easy to bring in leads from conduit. And there are no extra studs on the board to result in "hook-up confusion." Easier, more accurate wiring results. How much can this extra value save you?

702-80



BUY NOW FOR EXTRA VALUES

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Circle 513 on Page 19

The Inside Story of a Finer Pump...

Electro-magnetically balanced rotor cuts vibration, prolongs bearing life.

No seal

NOTE—
Fewer parts and to wear repair.

No packing or priming needed

Heavy duty pre-lubricated ball bearings require no further attention.

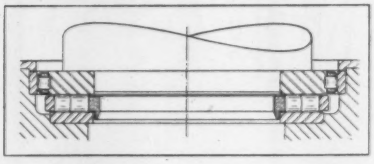
Model 11023E

Built Better to wear longer — Write for our complete catalog. There's a type and model to suit you.

THE Ruthman MACHINERY CO.

• COOLANT PUMPS
• CIRCULATORS • AGITATORS
• MOLTEN METAL PUMPS

1811 Reading Road Cincinnati, Ohio



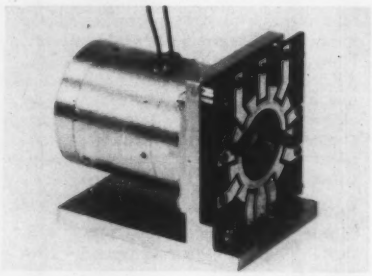
indrical rollers withstand operating temperatures to approximately 300 F. **Rollway Bearing Co.**, Dept. X-2561, 541 Seymour St., Syracuse, N. Y. D

Circle 684 on Page 19

Stepper Motor

steps nine times per revolution

New stepper motor has diameter of 1¼ in., is 1⅝ in. long, and weighs 4.5 oz. It steps nine times per revolution. Stepping mechanism provides mechanical locking of shaft except when coil is energized and shaft rotates. After step is completed, shaft is again mechanically locked even if power is maintained on coil, eliminating overshoot. Torque and stepping rate available from unit depend upon power available to operate motor. At 17.5 w input, unit produces 2.5 oz-in. torque and follows a 25-cps pulse with low-torque,



low-inertia load. Unit dissipates 16.25 w continuously at 125 C maximum ambient temperature. **Globe Industries Inc.**, 1784 Stanley Ave., Dayton 4, Ohio. G

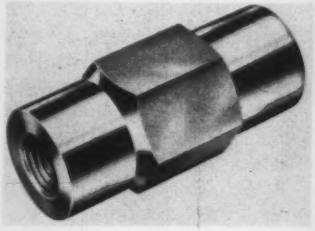
Circle 685 on Page 19

Bleed-Off Valve

automatically eliminates air in hydraulic circuits

New automatic air bleed-off valve operates in hydraulic circuits under pressures to 5000 psi. Valve automatically vents air to tank, assuring adequate pump priming and efficient circuit operation. Valve measures 2⅜ x 1 in. hex, and is avail-

able with ¼ in. NPT or 9/16-18 straight threads. Valve is installed in pump discharge line, ahead of all other components, with a T connection. Typical applications include use in hydraulic systems where a pump is required to prime against pressure in a blocked line, and in



dual-pump circuits where both pumps supply one system through check valves. **Denison Engineering Div., American Brake Shoe Co.,** 1160 Dublin Rd., Columbus 16, Ohio. G

Circle 686 on Page 19

Anchor Nuts

are miniature, two-lug floating types

Four miniature two-lug floating anchor nuts meet fastening requirements of miniaturized avionic equipment and applications where clearance or access is limited. Having reduced weight, height, and width, the nuts meet full tensile, vibration, twist-out, and push-up requirements of MIL-N-25027 (ASG) and are approved to AN-N-10. Low nut height and 0.060-in. counterbore in nut barrel permits use of lightweight, short thread length NAS bolts. LHTA521M is available in cadmium-plated, heat-treated carbon steel for use in temperatures to 550 F and is available in thread sizes No. 4-40, 6-32, 8-32, 10-32, and ¼-28. Type LHTA3300 is identical in configuration and thread size, differing in the use of A286 material which extends operating-temperature range to 900 F. Two additional nuts are for designs requiring standard miniature 3/32-in. rivets and rivet spacing in No.

New *** Revolutionary

GRATON AND KNIGHT NYCOR FLAT BELTING

NO STRETCH

NO TAKE-UPS

NO LOST PRODUCTION

CHROME LEATHER

LAMINATED NYLON CORE

CHROME LEATHER

Whatever your drive . . . you'll transmit maximum power longer with G&K Nycor belting. Your own tests will prove that Nycor belts deliver more horsepower over longer periods of time than ordinary transmission belting.

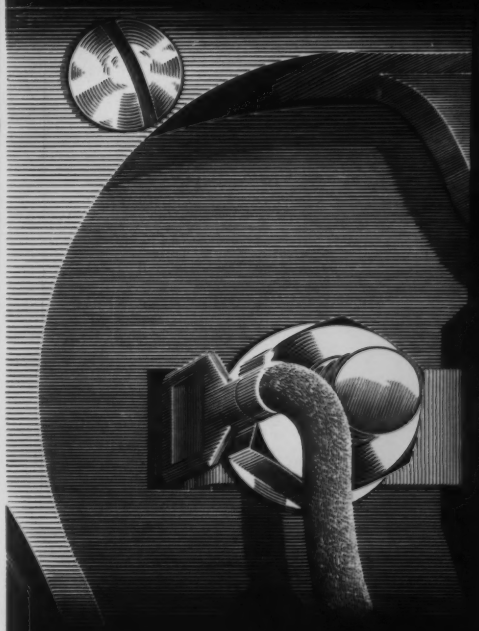
The stretchless feature of this belt eliminates take-ups and costly down time. In many instances conventional belting is replaced with Nycor at one half the width formerly used, reflecting tremendous savings on initial cost. LET US DEMONSTRATE THE DIFFERENCE!

Send For Brochure on Nycor Belting

GRATON & KNIGHT Company INC.
WORCESTER 4, MASSACHUSETTS

Circle 521 on Page 19

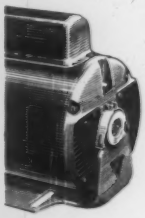
G-E fhp motor New Extra Value 4



FASTER CONNECTION

Now plug-in connectors on all terminals cut wiring time in half

For the first time on all single-phase Form G motors, General Electric offers time-saving quick connectors on *all* external and internal contacts.* Wiring time is cut in half. (Studs have been retained for conventional wiring.) Simply plug in the leads. Fast, positive connections are assured. Try it yourself. You'll like this new General Electric extra value.



*Explosion-proof and a few special motors excepted. 702-81

BUY NOW FOR EXTRA VALUES

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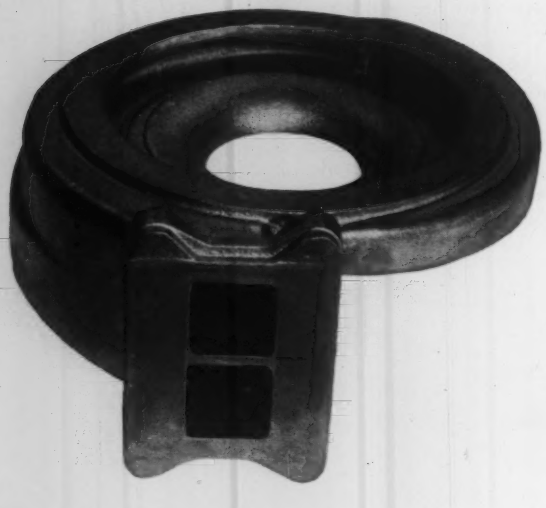
Circle 513 on Page 19



THERMAL SHOCK

A CASE IN POINT—This 20 pound Ni-Resist casting made for the Schwitzer Corporation by Hamilton Foundry is the turbine casing of a diesel engine turbocharger. Exhaust gases which turn the impeller at speeds up to 90,000 rpm subject the housing to rapid cyclic temperature changes up to 1500° F. Any free scale formed at these temperatures could erode and eventually destroy the impeller blades. Ni-Resist was chosen for this part because it produces practically no free scale, it resists growth and oxidation at high temperatures, and it resists cracking under thermal shock.

Ni-Resist iron combines three particular product engineering and design advantages. It resists oxidation: as low as .002 inches per year oxide penetration at 1400° F. Scale formed adheres to the base metal and reduces further oxidation to a minimum. It has high temperature strength: up to 12,000 psi at 1500° F. And it's the toughest of all flake graphite irons: Charpy impact strengths (unnotched) up to 150 ft.-lbs. Hamilton Foundry casts all types of Ni-Resist including Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and ntegrity of your foundry is your best insurance that specifications—and delivery schedules —will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD

HAMILTON FOUNDRY

The Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio • TW 5-7491

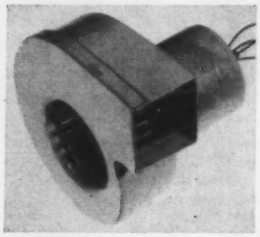
4-40 and 6-32 thread size. All four nuts offer 0.020-in. radial float of nut to compensate for possible misalignment of bolt holes. **Elastic Stop Nut Corp. of America**, 2330 Vauxhall Rd., Union, N. J. D

Circle 687 on Page 19

Blowers

for ac or dc applications

New blowers are available for dc or ac applications. They are furnished for dc with permanent-magnet mo-



tors in blower-wheel sizes 1 to 3 in. diam, or with ac motors, capacitor type, wheel size 1.5 to 4 in. Ac motors are available for 60 and 400 cycles. **Heinz Mueller Engineering Co. Inc.**, 1906 N. Cicero Ave., Chicago 39, Ill. J

Circle 688 on Page 19

Solid Epoxy Resins

have low sodium content

Designated 661, 664, and 667, three new solid epoxy resins are used in coating for appliances, auto body primers, cans, drums, tank cars, and for industrial maintenance. They can also be used in glass-reinforced laminates for aircraft structures, adhesives, and electrical printed circuits. Resins have a color rating of one maximum, providing extreme clarity. Low sodium content gives better electrical and coating performance. **Dow Chemical Co.**, Midland, Mich. H

Circle 689 on Page 19

Silicon Power Rectifier

for all types of power applications

Type 329 silicon rectifier provides average forward currents up to 160 amp per cell in single-phase circuits or 150 amp per cell in three-

make your next connection with

asg

UNIVERSAL JOINTS

They are made to provide smooth, more efficient transmission of power and are available from stock in 13 sizes with bored or solid hubs ranging from .375" to 4.000". Special bores, bores with keyways or setscrews are available upon special order.

The close limits to which all parts are held assure maximum load carrying capacity with durability and long life. Joints with hub diameters of .750" and larger have a self-closing snap ball oiler while the small pin is held in place with a self-locking snap ring. The snap ring simplifies assembly and disassembly.

Send today for Bulletin No. 527 describing the full line of ASG Universal Joints available from your nearest distributor.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY
HARVEY, ILLINOIS, U.S.A.

Circle 523 on Page 19

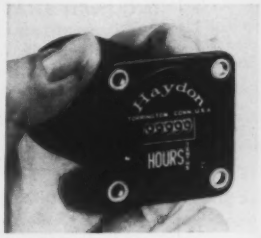
phase circuits, with maximum peak inverse ratings up to 500 v. Designed for all types of power applications, unit has high ambient temperature operation, long life, low regulation, rugged construction, and small size. Hermetically sealed cell is nickel plated to maintain low contact resistance and to prevent corrosion. In operation, rectifier case is cathode terminal. Each cell is provided with a ¾-in. threaded stud for easy mounting in any position. Cell is available in all types of rectifier-bridge assemblies for either forced-air or natural-convection cooling. **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa. F

Circle 690 on Page 19

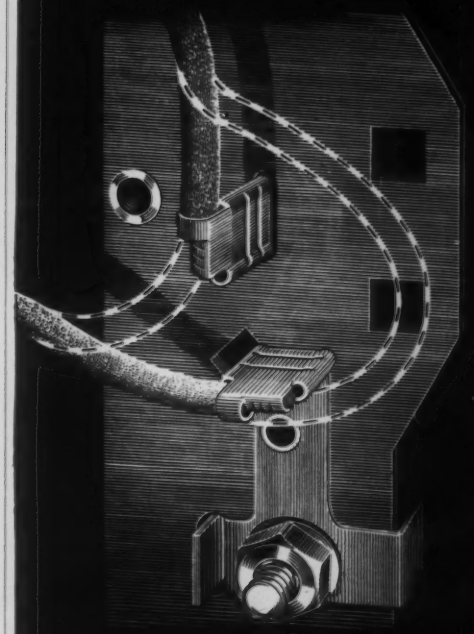
Elapsed-Time Indicator

is suitable for use on heavy industrial equipment

Series ED-71 elapsed-time indicator has wide application on machine tools, instruments, and other industrial equipment, on commercial communications equipment, and on almost any installation where an accurate record of operating time is required. Indicator is equipped with a direct-reading, five-digit counter that records hours and tenths of hours up to 9999.9 and then repeats. Weighing only 5 oz, with case dimensions of 1½ in. diam x 2 31/64 in. long, unit is suitable for applications to heavy industrial equipment. It withstands severe shock and vibration, and operates over a temperature range of −55 to 71 C. Equipped with a synchronous timing motor, unit is supplied for 120



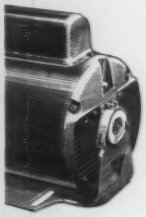
G-E fhp motor
New Extra Value 5



REVERSE ROTATION FAST

Now you can reverse Form G shaft rotation in less than 10 seconds

G-E Form G motors feature a new wiring method that lets you change rotation in seconds. Quick connectors make changeovers fast and positive. Just switch the two motor leads on the terminal board. That's all. No need to order special motors to meet your rotation requirements. Require fast, easy rotation changes? Ask about this extra value.



702-82

BUY NOW FOR EXTRA VALUE

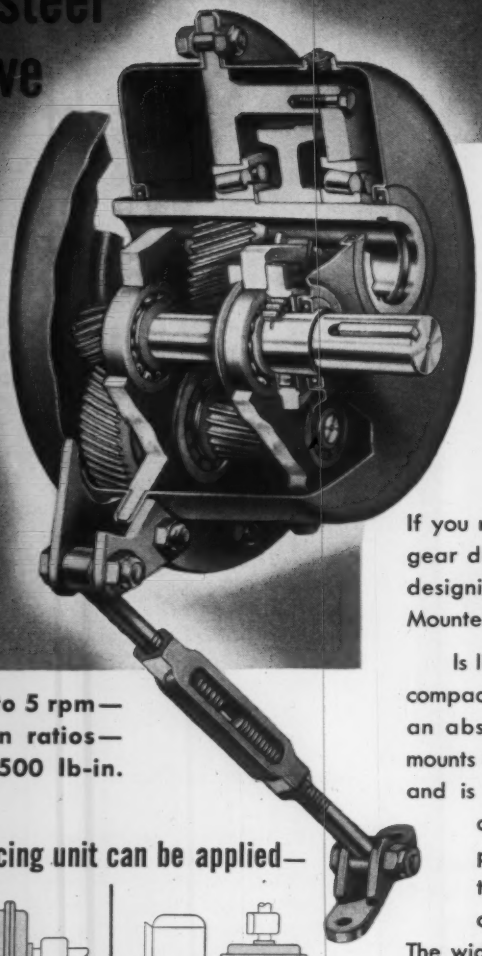
OPERATION up turn
GENERAL ELECTRIC

GENERAL ELECTRIC

Circle 513 on Page 19

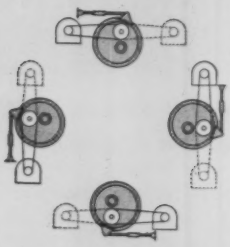
The FALK all-steel Shaft Mounted Drive

- *Versatile*
- *Efficient*
- *Economical*
- *Compact*

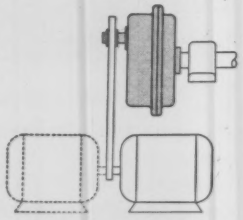


SEVEN SIZES—½ to 50 HP—420 to 5 rpm—single and two double reduction ratios—output torque ratings up to 31,500 lb-in.

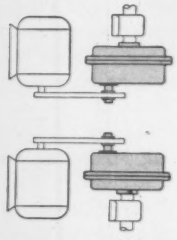
A few of the many ways this reducing unit can be applied—



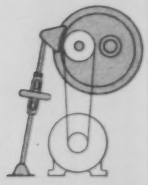
ANY POSITION



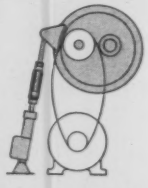
MOTOR EXTENDED —or below the unit



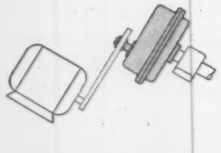
VERTICAL—UP or DOWN



VARIABLE SPEEDS... through use of variable-pitch sheaves—automatic belt adjustment with tie-rod adjustment



OVERLOAD RELEASE... that will slacken belts and cut off power if overload occurs



INCLINED SHAFT... Any standard unit can be mounted in vertical or inclined position by a simple rearrangement of oil drains

To Design men:

If you need an efficient, economical gear drive for the machine you are designing, the all-steel FALK Shaft Mounted Drive is your answer.

Is limited space a problem? This compact speed-reducing unit requires an absolute minimum of space. It mounts directly onto the driven shaft, and is driven through a V-belt or chain from any convenient power source. Unit can be positioned in countless ways, some of which are sketched below. The widest choice of output speeds is made possible by varying driving sheaves or sprockets.

Designed and geared by FALK, recognized leader in gear manufacture, this Shaft Mounted Drive will be a dependable component of your machine.

★

FALK Shaft Mounted Drives are available from factory stocks *from coast to coast.* See your Falk Representative—or write direct for copy of **Bulletin 7100.**

THE FALK CORPORATION, 3001 W. CANAL ST., MILWAUKEE 1, WIS.

Representatives and Distributors in Most Principal Cities

Manufacturers of

- Motoreducers
- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
- High Speed Drives
- Special Gear Drives
- Single Helical Gears
- Herringbone Gears
- Marine Drives
- Steel Castings
- Weldments
- Contract Machining

FALK

...a good name in industry

Circle 524 on Page 19

Here's Your
ABC's
ON THE NEWEST
ROTARY PUMPS

A SERIES
LOW TO MEDIUM VISCOSITY

High speed units to pump 3 to 25 gpm . . . low speed units 20 to 97 gpm. Maximum operating pressures to 100 psi. Gear, V-Belt or direct drives.

B SERIES
HAZARDOUS LIQUIDS

Sealed units U. L. Approved. High speed pump up to 23½ gpm . . . low speed pump to 90 gpm. Maximum U.L. pressure rating for hazardous fluids 50 psi. Gear, V-Belt or direct drives.

C SERIES
RUGGED DUTY
MEDIUM-HIGH VISCOSITY

Continuous operation packed pumps. Heavy outboard thrust bearing. Pump up to 211 gpm at pressures to 125 psi. Gear, V-Belt and direct drives. Threaded or flanged ports. Also Series "E" steamjacketed pumps.

D SERIES
RUGGED DUTY
MECHANICALLY SEALED

For broad group of liquids of wide viscosity range. Pump up to 211 gpm @ 450 RPM. May be operated at pressures to 100 psi. Gear or gear-motor drives. Threaded or flanged ports.

Wayne
PUMPS
THE WAYNE PUMP COMPANY
Industrial Division
FORT WAYNE 4, Indiana
Division of Symington Wayne Corporation

Circle 525 on Page 19

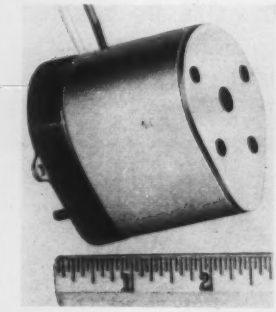
or 240 v ac at 60 cycles; power required at 120 v is 2.5 w nominal. Dielectric strength is 1000 v rms. **Haydon Div., General Time Corp.**, 245 E. Elm St., Torrington, Conn. B

Circle 691 on Page 19

Governor-Controlled Motor

for precise timing applications

Synchron Magnatorc dc governor-controlled motor is particularly suitable for missile timers and similar precision timing applications. It is available initially for 27-v applications. Motor has passed preliminary



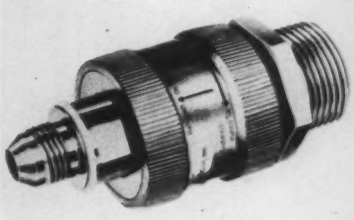
testing within ± 1¾ per cent maximum error over 24 to 30-v range, − 35 to 140 F, under shock and vibration conditions. **Hansen Mfg. Co. Inc.**, 1934 Virgil Blvd., Princeton, Ind. J

Circle 692 on Page 19

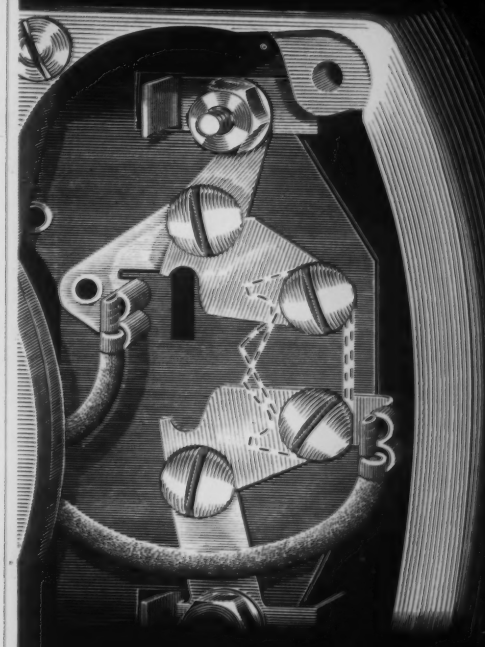
Self-Sealing Coupling

for 3000-psi hydraulic systems

Series 3200 self-sealing coupling is designed for 3000-psi aircraft hydraulic systems in accordance with MIL-C-25427. Quick connection is made with a quarter-turn of locking nut, and disconnection with a straight pull on nut. Coupling prevents partial connections, and a touch or glance tells whether coupling is connected and locked.



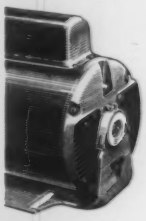
G-E fhp motor
New Extra Value
6



SWITCH
VOLTAGE FAST

Unique sliding plates on terminal boards simplify voltage changeovers

You can switch G-E Form G motors from 115 v to 230 v operation (or vice versa) in ⅕ the time, without confusion and error, using only a screwdriver. Just loosen four screws, slide plates to new position, and tighten screws. Simple! No special tool are needed. Does your product operate on both voltages? If so, this *extra value* is for you. 702-83



BUY NOW
FOR EXTRA
VALUES

OPERATION up turn
GENERAL ELECTRIC

GENERAL ELECTRIC

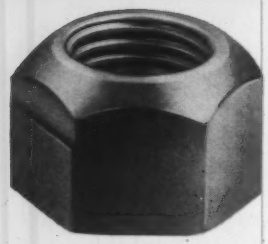
Circle 513 on Page 19

Don't pay "special" prices for "standard" fasteners

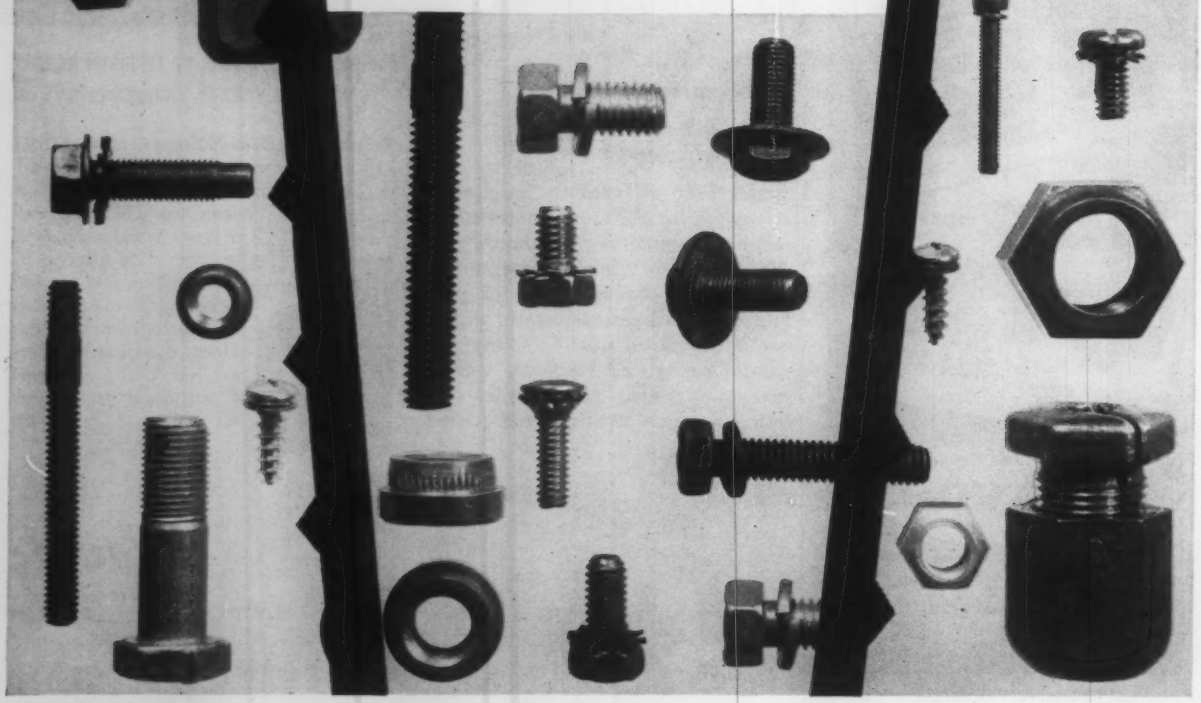
When a fastener is produced in volume at Lamson & Sessions it is a "standard". You are not charged "special" prices. Nor do you have to wait unreasonable lengths of time for delivery. Orders for "specials" are often filled from stock. Regardless of type all fasteners are manufactured at Lamson with strict adherence to statistical quality control techniques. Your order will come from one of four plants—two of them brand new and almost entirely automated. If you think you've been paying more than you should for fasteners ask us about it. You'll probably be pleasantly surprised with our answer.

The Lamson & Sessions Co.

5000 Tiedeman Road, Cleveland 9, Ohio • Plants at Cleveland and Kent, Ohio • Chicago • Birmingham



Stover Locknut



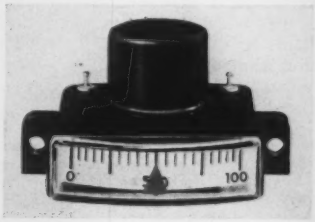
Other advantages include positive action, no fluid loss, exclusion of dirt and moisture, and simplicity of construction. **Aeroquip Corp.**, Jackson, Mich. H

Circle 693 on Page 19

Panel Meter

provides large display in small space

MCE-1 edgewise meter is one of a line designed for control-panel applications where space is limited but large display is required. Meter has clear Plexiglas front and large triangular pointer that is easily seen on a scale 1 7/16 in. long. Weighing only 1½ oz, meter is available in current and voltage ranges of 100 ma to 1 amp and 1 to 300 v. **Marion Electrical Instrument Co.**, Grenier Field, Manchester, N. H. B



Circle 694 on Page 19

Snap Switch

uses low gradient spring members

Cemco switch employs a snap-switch principle in which low gradient spring members are used to reduce material stresses and insure long life. Less force is required to deflect spring a given distance than for springs with higher gradient. Main blade of the switch is constructed so that spring forces are divided between two legs, one on each side of center blade, thus eliminating bending moments. Symmetrical construction of main blade requires that movable end travels in a straight line parallel to direction in which actuator pin moves, giving closer movement differentials. Center blade, under compression at all times, undergoes a bowing movement in section of spring behind contacts. Thus contacts move slightly in a lateral direction prior to tripping of mechanism.

NEW
DIXON AUTO-TORQUE *Driver*

SCREWS AND NUTS AUTOMATICALLY DRIVEN WITH PRECISE TORQUE CONTROL

Gives you . . .

1 Complete control of screws from parts feeder to chuck, until threads are started. No dependence on gravity to load chuck.

2 Exclusive built-in sensing, assures that screw is driven. Automatically retracts driver only after attaining proper torque.

3 Complete automatic cycle, requires only a touch of the pedal.

4 Torque accuracy within 5%, comparable to most precise hand-torquing methods.

5 Clutch free-wheels after driving. Operator cannot vary the torque.

6 Two ranges of torque available 0 to 84 inch-pounds and 48 to 120.

7 Work height adjustment with 14" range, can be made without in any way disturbing the machine adjustments.

Model SD-100, above, tooled for any standard screw up to ¼" thread size. Special tooled feeders available. Model SD-101, without floor column, provides a complete automatic station. Maximum width 6 inches.

The new DIXON *Auto-Torque Driver* includes all the features of the DIXON Auto-Positioner, and has an efficient space-saving air motor with an adjustable-torque clutch. These features provide for *positive* handling, giving new efficiency in driving screws and nuts.

ASK FOR BULLETIN SD-B1 illustrating and describing design and operating features and giving specifications.

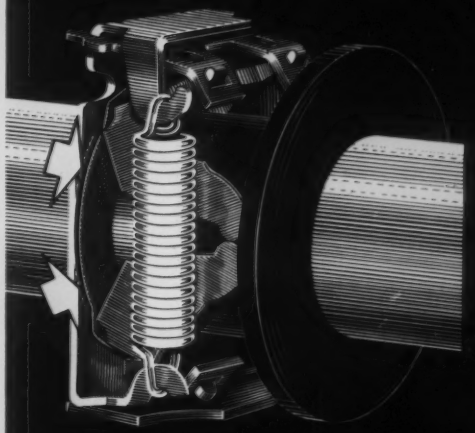
DIXON AUTOMATIC TOOL, INC.

DIXON 2310 - 23rd AVENUE ROCKFORD, ILLINOIS

Equipment for Automatic Parts Handling and Assembly

Circle 527 on Page 19

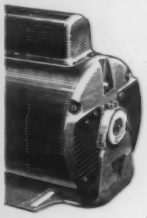
G-E fhp motor New Extra Value 7



QUIETER SWITCHING

Specially designed washer effectively cushions start-stop switch click

The Form G's centrifugal switch is even quieter than before! A carefully designed composition washer now greatly reduces start-stop click without sacrificing positive snap action. Add this to a switch that's dependable and rugged (3½ million test operations) and you get real extra value. Give it a listen. See if you notice a difference. Your customers will. 702-84

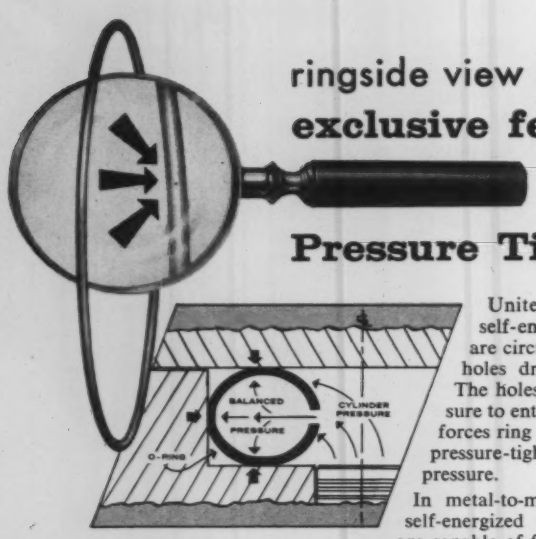


BUY NOW FOR EXTRA VALUES

OPERATION up turn GENERAL ELECTRIC

GENERAL ELECTRIC

Circle 513 on Page 19



ringside view of United's **exclusive feature** for

Pressure Tight Seals

United's exclusive, patented* self-energized metallic O-rings are circular tubes vented by tiny holes drilled in the ring wall. The holes allow contained pressure to enter the ring which then forces ring wall to form positive pressure-tight seals under high pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive static seals under extreme temperatures from —321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes, 3/8" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings; and wire and brazing O-rings. Write for free 22-page booklet (on your letterhead please).

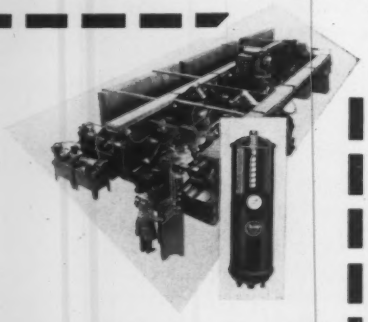
PATENTS 2,809,269; *2,837,360

UNITED METALLIC "O" RING CORP.
Dayton, Ohio • Box 1035
Division of United Aircraft Products, Inc.

Circle 528 on Page 19

IF YOU DESIGN OR OPERATE MODERN ACCURACY-DEMANDING EQUIPMENT . . . FIND OUT WHAT "BRIGGS HYDRAULIC CONTROL" REALLY MEANS.

. . . A LITTLE lost pressure here . . a sticking valve there, yes, contamination can raise havoc with even the simplest device . . BUT properly designed and engineered HYDRAULIC CONTROL can whip the weakest link in any producing chain. A complete Briggs operating manual is yours for the asking.

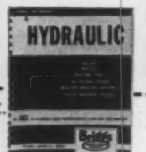


Showing 25 station Le Maire "PRODUCER." Completely machines three different styles of truck manifold castings in 55 seconds. Briggs hydraulic filter installed on all of these Le Maire "PRODUCERS."

Briggs PIONEERS IN MODERN OIL FILTRATION

OIL FILTERS
• FILTER/SEPARATORS • HYDRAULIC FILTERS • AIR/GAS LINE FILTERS

PRODUCT RESEARCH BOOSTER

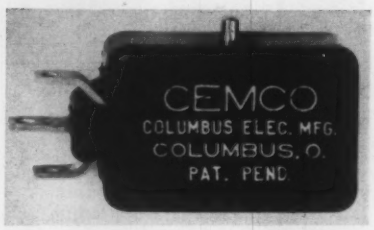


WRITE, TODAY, NO OBLIGATION.

THE BRIGGS FILTRATION COMPANY, DEPT. 266, WASHINGTON 16, D. C.

YES! Please send operating manual at no cost or obligation.

Name .....
Company .....
Address .....



Contact wipe helps break minute welds caused when electric circuit is closed. **Columbus Electric Mfg. Co.**, 2005 E. Main St., Columbus 5, Ohio. G

Circle 695 on Page 19

Shaft Seal

for small water and oil pumps

New automatic shaft seal, intended primarily for small water and oil pumps, can also be used in other applications to prevent leakage of liquid around a rotating shaft. Designated Type J-2, it is available in sizes for 5/8 and 1 1/8-in. shafts. Maximum design pressure is 60 lb. Molded alloy carbon washer with enlarged driving area provides positive contact and long life. Washer will not score, seize, or warp, is unaffected by changes

in temperature, and withstands antifreeze, acids, and other chemical solutions. Seal is interchangeable with most standard units. **Schwitzer Corp.**, Indianapolis, Ind. J

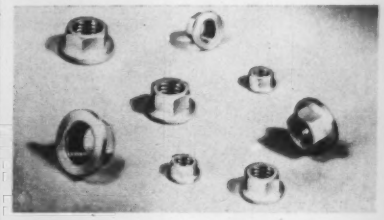
Circle 696 on Page 19

Cold-Forged Nuts

are lighter than sheet metal

New lightweight locknuts, designated FN-12, are cold-forged units of the prevailing-torque type. Nuts use minimum amount of metal needed to develop rated ultimate tensile strength of 125,000 psi. They are much lighter in some sizes, yet just as strong as sheet

metal and AN-series nuts. Applications include use with aircraft tension and shear bolts in structural and sheet-metal assemblies, bulkhead mountings of major components, and in other airframe and aircraft-engine applications. Hexagonal wrenching surface permits installation with a variety of standard wrenches. The alloy-steel nuts are available initially in sizes No. 4 to 3/8 in. They are available



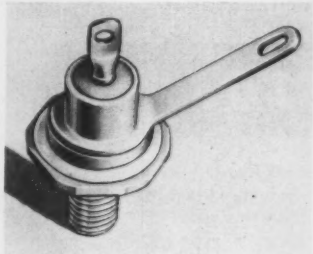
cadmium plated, either with or without molybdenum disulfide high-temperature coating. New locking feature gives closer control over tightening torque and eliminates burrs. **Standard Pressed Steel Co.**, Box 102, Jenkintown, Pa. C

Circle 697 on Page 19

Silicon Rectifier

incorporates built-in insulation

New diffused-junction silicon rectifier has built-in insulation that electrically isolates semiconductor from head and screw of mounting stud. Stud screw can be threaded directly into the heat sink, and heat dissipation is more efficient and uniform. Bonded contact between case and heat sink provides direct paths of thermal conductivity. Several rectifiers can be mounted directly on same heat sink to form bridge, center-tap, and other circuits that are electrically insulated from heat sink. Electrical insulation consists of a ceramic disc embedded between base of case and stud head. Thermal resistance is less than 2 C per w.



for a
SURE, EASY START
with
SHALLOW PENETRATION
you want
AIRCO 90C

* Airco 90C all-position electrodes are unusually efficient where penetration must be shallow.
* Weld storage tanks, air frames, metal furniture, a broad range of sheet applications.
* Weld the bulk of jobs done by garages, small shops, and on farms.

Airco 90C electrodes give a sure and easy arc start. Operate without interruption on transformers of low open circuit voltage, or on DC, either polarity. Give a smooth, uniform, convex deposit.

FREE — Send for the handy Airco Electrode Guide. It will help you select the right electrode for your specific job. Request catalog 1318.

Authorized Airco Dealers in principal cities

AIRCO

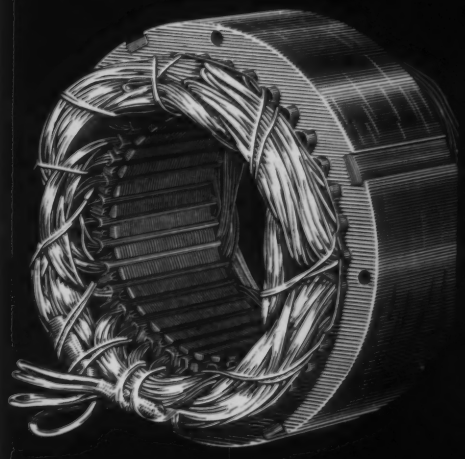
AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated

150 East 42nd Street, New York 17, N. Y.

Circle 530 on Page 19

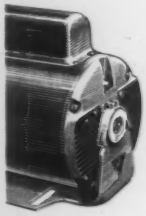
G-E fhp motor New Extra Value 8



LONGER LIFE

Heavy-duty bonding dip and stator clamps provide rigid, unitized assembly

Along with the Mylar*-Formex** insulation system pioneered by G.E., you now get a new bonding treatment on Form G motor stators. It affords added protection against every type of stress. Stator cores are now specially clamped for highly accurate alignment. These new features result in extra rigidity, more uniform quality. Here's longer motor life!



*Reg. trade-mark, DuPont Co.
**Reg. trade-mark, G.E. Co.

702-85

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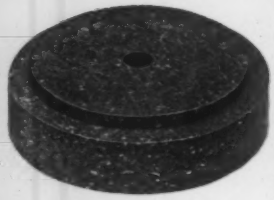
Circle 513 on Page 19

WORLD BESTOS BRAKE LINING

... any *shape* ... any *size* ... any *friction* to meet your most exacting requirements!

ROUND

as for Race Cars



INTRICATE

as for Industrial Brakes

TINY

as for small Precision Assemblies

BIG

as for giant Forming Presses

● World Bestos is currently helping many manufacturers solve difficult braking problems with special friction formulas that assure dependable stopping power, non-fading performance and extra long life.

World Bestos offers extensive research and development facilities and more than 30 years' specialization in friction material manufacture. Modern, high-capacity plant assures on-schedule delivery.

● **Write for new Industrial Brake Folder . . . or let us know your specific requirements. Send prints and specifications if possible. Engineering assistance available.**

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE **Firestone** TIRE & RUBBER CO.

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

Circle 531 on Page 19

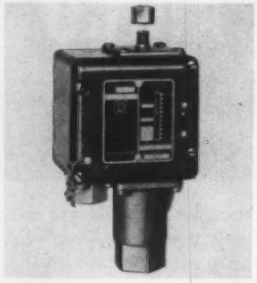
Two types are available for 3 and 10-amp service at 100 C case temperature in voltage ratings to 600 v peak inverse. Unit measures about ¾ in. in height, and ½ in. across flat of hex head. **Bradley Laboratories Inc.**, 168 Columbus Ave., New Haven 11, Conn. B

Circle 698 on Page 19

Pressure Switch

for high-pressure hydraulic systems

No. 5000 pressure switch for high-pressure hydraulic systems incorporates a strain-relief mechanism to prevent damage from the shock of violent pressure surges. Pressure range is adjustable from 550 to 5000



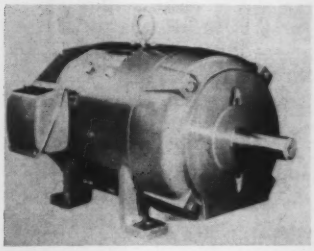
psi. Operating rates of up to 300 per minute are possible. Oiltight construction prevents oil leakage into enclosure. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 699 on Page 19

DC Motors and Generators

have high-temperature silicone insulation

Life-Line H Series dc industrial motors and generators are equally effective as basic prime movers or as elements of complex automatic production systems. Units have dripproof enclosures as standard and bear NEMA Class B ratings. Motor ratings range from 1 to 150 hp and generator ratings from ¾ to 100 kw. High-temperature silicone insulation system provides long insulation life. Controlled ventilation system draws air from drive end, distributes flow positively throughout the machine, and expells air at commutator end. Armature inertia has been decreased by as much as 55 per cent in some ratings, and commutating



ability has been increased by 35 per cent. Housing is designed for maximum protection and simplified installation and maintenance. **Westinghouse Electric Corp.**, P. O. Box 2278, Pittsburgh 30, Pa. F

Circle 700 on Page 19

Clad Wear Plates

have ¼-in. thick aluminum bronze cladding

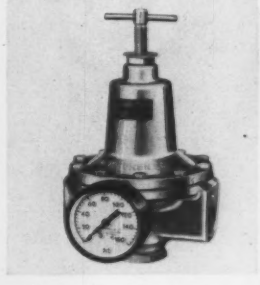
O-Kni-Co clad aluminum-bronze wear plates are a combination of ¼ in. thick aluminum bronze externally clad to a tough, easily machinable steel backing. They are available in 14 standard cross sections from ½ to 1¼ in. in thickness, 1½ to 8 in. width, and up to 72 in. in length. Applications include use as slides in cam and trim dies, or wherever there is a sliding action between flat metal parts. **Ohio Knife Co.**, Dept A-80, Cincinnati 23, Ohio. G

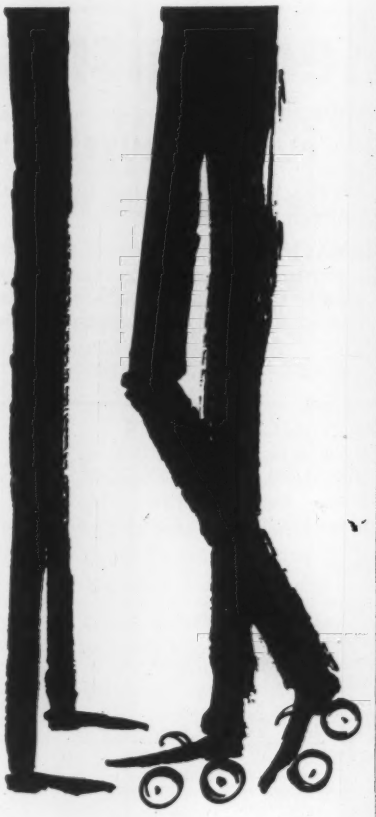
Circle 701 on Page 19

Water-Pressure Regulators

for large-volume flow

Series 20 AP corrosion-resistant water-pressure regulators provide accurate pressure control in spite of fluctuations in primary pressure and rates of water flow. They are designed for large-volume flow and for quick response to sudden demands for greater volume. They are available in pipe sizes from ¼ to 1 in.,





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See what the closest man on wheels, backed by the production capacities and qualities of an automated operation and years of experience, can do for you.

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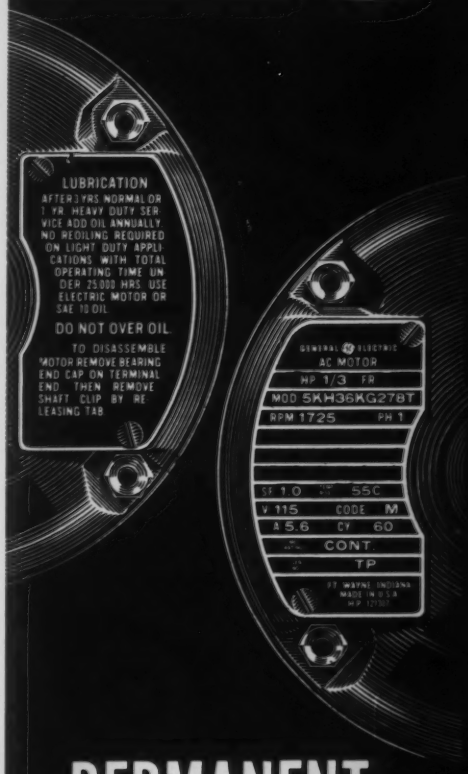
DIVISION OF THE FIRESTONE TIRE & RUBBER COMPANY

Circle 532 on Page 19

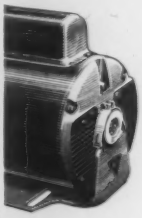
G-E fhp motor New Extra Value 9


LUBRICATION
AFTER 3 YRS NORMAL OR 1 YR HEAVY DUTY SERVICE ADD OIL ANNUALLY NO REOILING REQUIRED ON LIGHT DUTY APPLICATIONS WITH TOTAL OPERATING TIME UNDER 25,000 HRS USE ELECTRIC MOTOR OR SAE 10 OIL
DO NOT OVER OIL
TO DISASSEMBLE MOTOR REMOVE BEARING END CAP ON TERMINAL END THEN REMOVE SHAFT CLIP BY RELEASING TAB
GENERAL ELECTRIC
AC MOTOR
HP 1/3 FR
MOD 5KH36KG278T
RPM 1725 PH 1
SF 1.0 55C
V 115 CODE M
A 5.6 CY 60
CONT
TP
FT WAYNE INDIANA MADE IN U.S.A.

PERMANENT DATA

Easy-to-read instructions and data simplify installation and servicing

Operating data on Form G motors is both legible and permanent to help you select, install and service without guesswork. The nameplate is engraved, then paint-filled for extra readability. Oiling instructions are lithographed on the terminal box cover plate. Lets your customers know exactly how *little* maintenance is required. *See* this extra value!



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Circle 513 on Page 19

Fifth Conference on Mechanisms

cosponsored by Purdue University and *Machine Design*

OCTOBER 13-14, 1958 • Lafayette, Indiana • PURDUE UNIVERSITY

PURPOSE of this continuing series of Conferences is to promote better understanding, design and application of mechanisms. All designers and engineers interested in the design and development of mechanisms are cordially invited.

ADVANCE REGISTRATION may be completed with the form below. The fee of $35.00 includes a banquet on October 13 and a luncheon on October 14, as well as a copy of the *Conference Transactions*.

HOUSING RESERVATIONS may be made with the Union Club on the Purdue campus by the form below. Rooms are also available at the Fowler Hotel in Lafayette (write direct), or those driving may prefer Morris-Bryant Motel, Cedar Crest Motel, or Green Acres Motor Court (all 2-4 miles north on U. S. 52).

MONDAY, OCTOBER 13

10 a.m.
SESSION 1—Fowler Hall—Memorial Center

EUROPEAN REPORT
Prof. J. Denavit, Northwestern University

SPACE MECHANISMS
Dr. Rudolf Beyer, professor of kinematics and mechanism design, Technical University, Munich, Germany

1:30 p.m. SESSION 2A — Room 206, Memorial Center
1:30 p.m. SESSION 2B — Fowler Hall, Memorial Center
1:30 p.m. SESSION 2C — Room 214, Memorial Center

Session 2A

CYCLOIDAL CRANKS
E. H. Schmidt, senior mechanical consultant, E. I. du Pont de Nemours & Co.

INFLECTION CIRCLE AND POLODE CURVATURE
Prof. A. S. Hall Jr., Purdue University

APPLYING THE INFLECTION-CIRCLE CONCEPT
Prof. James C. Wolford and Prof. Donald C. Haack, University of Nebraska

Session 2B

DYNAMIC ANALYSIS OF CAM MECHANISMS
Prof. Ray C. Johnson, Yale University

CAM TORQUE CURVES
Prof. Harold A. Rothbart, City College of New York

PIVOTED-FOLLOWER CAM SYSTEMS
Robert L. Droke, associate engineer, International Business Machines Corp.

Session 2C

A MECHANICAL SQUARING DEVICE
Sigmund Rappaport, project supervisor, Ford Instrument Co.

MECHANICAL ANALOG COMPUTER COMPONENTS—1
George W. Michalec, section head, General Precision Laboratory Inc.

6:30 p.m.
BANQUET—Ballroom—Memorial Union Building

THE FUTURE OF AN ENGINEER
Dr. Richard W. Wallen, director, managerial training division, Personnel Research & Development Corp., Cleveland

TUESDAY, OCTOBER 14

8:30 a.m. SESSION 3A — Room 206, Memorial Center
8:30 a.m. SESSION 3B — Fowler Hall, Memorial Center
8:30 a.m. SESSION 3C — Room 214, Memorial Center

Session 3A

FOUR-BAR FUNCTION GENERATORS
Prof. Ferdinand Freudenstein, Columbia University

POINT-POSITION-REDUCTION
C. Wesley Allen, engineer, General Electric Co.

THE FECUND FOUR-BAR
Prof. R. S. Hartenberg and Prof. J. Denavit, Northwestern University

Session 3B

CAM-DESIGN TABLES
C. N. Neklutin, vice president, Universal Match Corp.

DISC-CAM CURVATURE
J. Hirschhorn, school of mechanical engineering, New South Wales University of Technology, Sydney, Australia

HIGH-SPEED SPRING-ACTUATED CAMS
Philip Barkan, engineering research and development laboratory, Switchgear and Control Div., General Electric Co.

Session 3C

MECHANICAL ANALOG COMPUTER COMPONENTS—2
George W. Michalec, section head, General Precision Laboratory Inc.

NONCIRCULAR GEARS
Frederick W. Cunningham, president, Cunningham Industries Inc.

12:15 p.m.
LUNCHEON—Ballroom—Memorial Union Building

THE ENGINEER'S FUTURE
J. F. Young, general manager, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

1:45 p.m.
SESSION 4—Fowler Hall—Memorial Center

MEASUREMENT AS A DESIGN TOOL
F. E. Fisher, manager, Electrical Analysis and Mechanical Analysis Lab., International Business Machines Corp.

MICROMOTION ANALYSIS VIA HIGH-SPEED MOVIES
William G. Hyzer, consulting research engineer, Janesville, Wis.

Mail to: MECHANISMS CONFERENCE, Comptroller's Office (Conferences), Purdue University, Lafayette, Ind.

233.903

ROOM RESERVATION

Please reserve in the Union Club the accommodations checked:
Nights: Oct. 12 ☐ Oct. 13 ☐
Single Bed—Bath ☐
If necessary, will share twin-bed room with another Conference member ☐
Twin Beds—Bath ☐
Room will be shared by _____

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Company _____
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CONFERENCE REGISTRATION

The following persons plan to attend the Mechanisms Conference, October 13 and 14, 1958 (name and title, please):

Fee enclosed

_____ ☐
_____ ☐
_____ ☐

$_____ is enclosed for the registrations checked at $35 each. (Make checks payable to Purdue University.)

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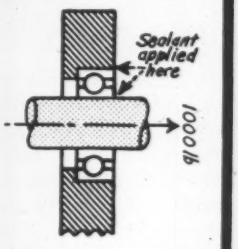
Name _____
Company _____
Address _____

Edwin F. Oblinger, Chief Engineer, Parker Sweeper Company, says:

"WE THREW OUT PRESS FITS FOR BEARINGS..."

"We used interference fits to prevent bearing races from turning in the gear box of our 4HP Turbosweeper. Maintaining close tolerances was a constant headache. If the fit was loose, the race would slip and fret the surfaces; if the fit was tight, the race would deform and bearing life would be shortened. Then we discovered LOCTITE Liquid Sealant would do away with the need for press fits. We opened up the tolerances for both shaft and housing and used a slip fit, filling the clearance with LOCTITE. The bearings are retained with a force equal to the customary interference fit, but we've reduced rejected parts from 8% to less than 1% and reworked parts fell from 20% to 0! Field reports are excellent."

LIQUID SEALANT ... replaced interference fits and opened up tolerances almost 0.002 in. on shaft and housing for this ball bearing assembly. Load of over 1000 lbs. is needed to break bond.



LOCTITE is a penetrating liquid that hardens only after being confined between closely fitted metal parts. In the absence of air, the sealant hardens into a strong, heat and oil-resistant bond. The hardening action may be accelerated by heating.

LOCTITE eliminates the need for interference fits on bearings, sleeves, shafts and studs ... locks nuts to bolts, seals pipe and tubing joints. For further information write to:

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 534 on Page 19

with pressure ranges of 0-50, 0-125, and 0-250 psi. Each is suitable for line pressures to 400 psi and temperatures to 200 F. **C. A. Norgren Co.**, 3400 S. Elati St., Englewood, Colo. K

Circle 702 on Page 19

Servo Motor

size 6 unit weighs 0.9 oz

Size 6 servo motor is for applications where high response and size and weight limitations are of importance. Weighing only 0.9 oz, motor develops stall torque of 0.125 oz-in., and has free speed of 6200 rpm. It is available for 400-cycle operation with 26, 33, or

52-v control-phase windings. Control phase is center-tapped for operation directly with transistor amplifiers. Operating temperature range is − 55 to 120 C. **Daystrom Transicoil Corp.**, Worcester, Montgomery County, Pa. E

Circle 703 on Page 19

Multiplier Phototube

for headlight control service

No. 7117 multiplier phototube is a nine-stage type, designed for dc automobile headlight-dimming service. It has instantaneous response to meet timing requirements of headlight-control service, and provides stable performance over long periods. Spectral response covers approximate range from 3000 to 6200 angstroms, with maximum response

Full line of G-E Form G motors

10

NOW WITH NEW EXTRA VALUE

Contact Your G-E Sales Engineer Today

Want more information about the new extra value features on General Electric Form G motors? Your General Electric Sales Engineer has all the facts. He also has a complete time schedule of the availability of these features on the motors for your applications. Why not call him today?

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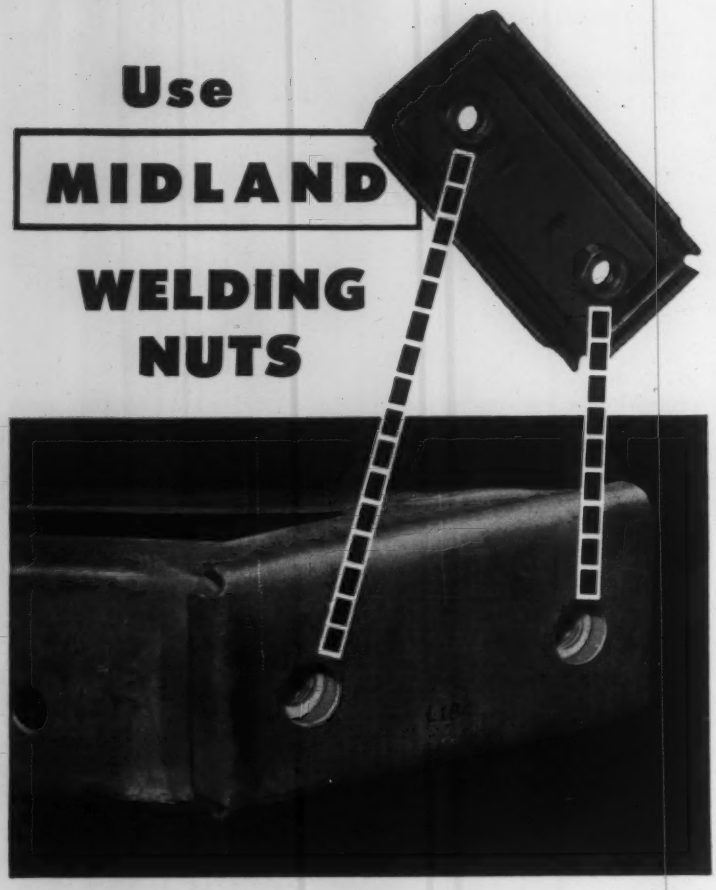
Circle 513 on Page 19

Use
MIDLAND
WELDING
NUTS



For Places
a Wrench Can't Reach

Before you "button-up" a sub-assembly, make sure Midland Welding Nuts are pre-mounted in places a wrench can't reach. Welded in place, Midland Welding Nuts save time, costs, and the need for a second man at assembly. Quality goes up, too, for Midland Nuts can't come loose or rattle.

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Want cost and time-saving tips? Send for the free booklet showing you how to "Save with Midland Welding Nuts."

MIDLAND-ROSS CORPORATION
WELD NUT DIVISION
6660 MT. ELLIOTT AVENUE • DETROIT 11, MICHIGAN

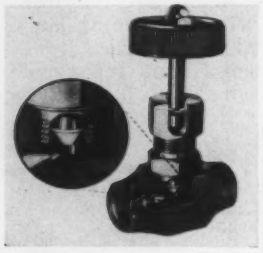
at about 4000 angstroms. When operated with a supply voltage of 1000 v dc, tube has a median luminous sensitivity of 35 amp per lumen. Maximum over-all length is 3.12 in. and maximum diameter is 1.32 in. **Tube Div., Radio Corp. of America**, Harrison, N. J. D

Circle 704 on Page 19

Small Valves

have plastic stem points

Series 270 bar-stock small valves offer a choice of either nylon or corrosion-resistant Kel-F plastic pointed stems. Plastic tips meet applicable military specifications for valves used on high-pressure compressors, and provide vapor or vacuum leak-tight closure, with mini-



mum opening pressure surges. Maximum pressure rating is 5000 psi. Plastic tips are available on $\frac{1}{8}$ and $\frac{1}{4}$-in. valves, and there is also a choice of O-ring stem seal or Teflon packing. All valves can be panel mounted. **Hoke Inc.**, Tanakil Road, Crasskill, N. J. D

Circle 705 on Page 19

Potentiometer

subminiature unit
measures 3/16 x 5/16 x 1¼ in.

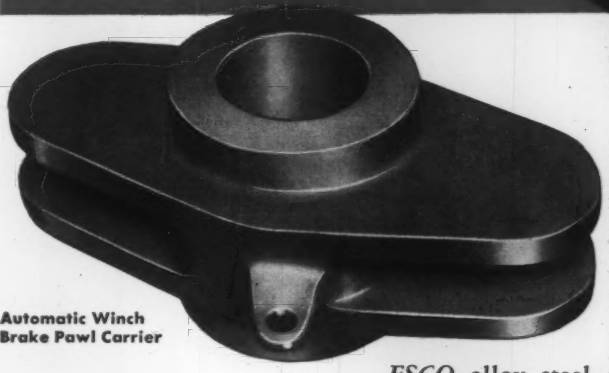
Trimpot 224 subminiature wire-bound potentiometer operates at high temperatures and under conditions of extreme humidity and vibration. Designed for application in missiles and high-speed aircraft, unit measures only 3/16 x 5/16 x $1\frac{1}{4}$ in. Body eyelets are on 1-in. centers for standard mounting. Plastic case permits humidity resistance in excess of MIL-STD-202A requirements. Power rating is 1 w at 70 C and $\frac{1}{2}$ w at 125 C. Operating temperatures range from −65 to 175 C. Self-locking 25-turn adjustment is virtually immune to shock and vibration. Unit can be

Circle 535 on Page 19

BEFORE YOU SAY

"IT CAN'T BE CAST"

Transmission Shifter Fork



Automatic Winch
Brake Pawl Carrier

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ESCO alloy steel castings can make your designing *easier*. You get the part you want, in the alloy you need and in the shape that saves you the most fabricating, machining and finishing time.

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Circle 536 on Page 19

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for the first time . . .

a basic discussion of bellows design criteria including a slide calculator to provide a short cut to approximate bellows design. Made available by the The Belfab Corporation — the leader in the field of precision welded bellows. Price, one dollar.

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Gentlemen:
Please send a copy of the new 24-page Bellows Design Manual with Slide Calculator. Please find $1.00 enclosed.

Name..... Title.....

Company.....

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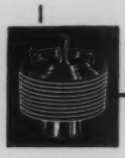
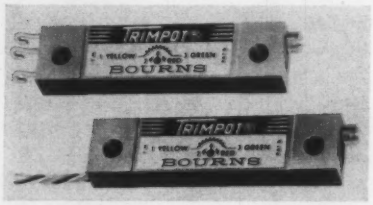
City..... State.....



THE BELFAB CORPORATION

Daytona Beach, Florida



mounted directly to printed-circuit boards or other flat surfaces. It is available with solder lugs, printed-circuit pins, or insulated stranded leads. Standard resistances are 100, 200, and 500 ohms, and 1000 to 50,000 ohms. **Bourns Laboratories,** P. O. Box 2112, Riverside, Calif. L

Circle 706 on Page 19

Plastic-Felt Materials

for mechanical applications

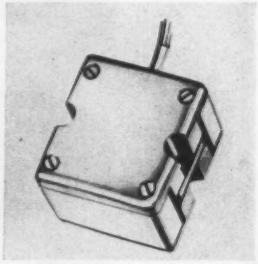
Three styles of nonwoven synthetic-felt combinations, called PlastiFelts, are available for mechanical applications. N-50 treated all-wool felt has each fiber encased in a protective sheath of nylon, providing long life, excellent resistance to abrasion and friction, and added strength without increased density. A second style uses a polyethylene film surface which prevents surface-fiber shedding, provides a grease and oil-resistant surface, and stops air travel through the felt. Third is a Teflon-coated felt which provides low friction and high heat resistance. Teflon is self-lubricating so that material surface forms an actual bearing surface in rotating apparatus. **Felters Co.,** Dept. GH, 210 South St., Boston 11, Mass. B

Circle 707 on Page 19

Torque Motor

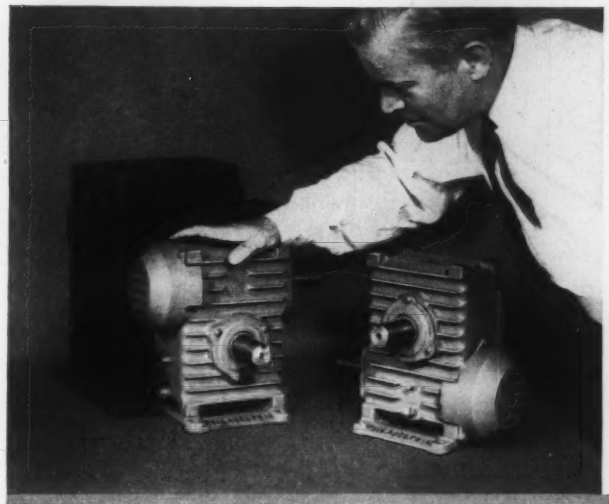
for applications requiring high-response transducer

New, lightweight torque motor is available with various rates of mid-position force, coil resistance, and



Circle 537 on Page 19

new high capacity fan cooled reducers take up 50% less space



LOOK AT THE SPACE YOU SAVE!

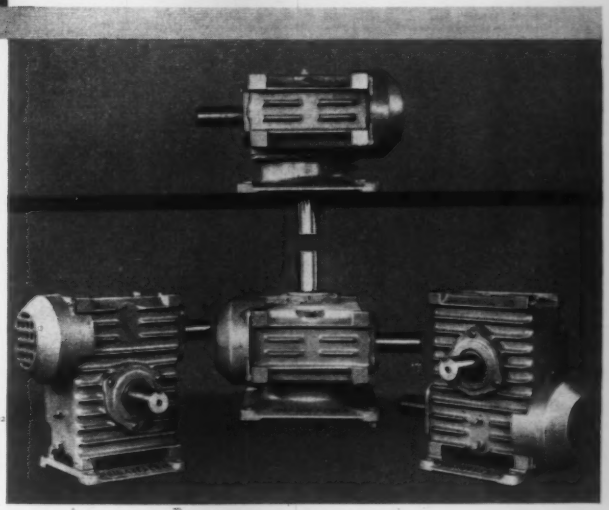
Think what this can mean to your products! You can make important savings in space and weight . . . in the neighborhood of 50% . . . depending upon output torque requirements. Or, you can design for heavier loads . . . up to 80% . . . without adding an ounce of weight to your product. You get more horsepower per dollar!

This new line of Philadelphia Fan cooled Worm Gear Reducers is available in 3, 3½ and 4" center distances for ratios from 5 1/6:1 to 60:1. Fan cooling, sturdy finned housings, improved tooth forms, precision ground alloy steel worms and special high strength bronze gears all combine to give you a drive that will handle heavier loads in less space.

STANDARD STOCK PARTS SIMPLIFY SELECTION.

These new fan cooled units have a degree of simplicity and flexibility never before available. Standardized housings, fans, gearing and mounting bases permit you to select any drive arrangement you need . . . permit us to give you prompt delivery from stock.

They simplify your design problems too. For Example: horizontal units can be furnished without mounting bases. Housings can be designed as an integral part of your product.



For more information . . . horsepower ratings . . . dimensions . . . construction details . . . write for your copy of Bulletin WG-583.

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Circle 538 on Page 19

STEEL CASTINGS* help build dependability into the modern cargo carrier . . .

*...Specifically **UNITCASTINGS!**

Transporting America's products by truck-trailer is a gigantic, ever-increasing task—calling for dependable, rugged, long-lasting equipment. This is the reason many manufacturers of over-the-highway carriers specify *foundry engineered UNITCASTINGS* for many component parts.

High quality cast steel affords intricate, one-piece designs . . . offers uniformity and strength for longer life, less maintenance, and more dependable product service.

And . . . *foundry engineered UNITCASTINGS*, produced by superior methods, assure steel castings that are internally sound . . . surfaces that are clean and dimensionally accurate . . . and require minimum finishing. Lower *finished* cost is the *real* advantage of specifying UNITCASTINGS. Write for complete information today!

UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

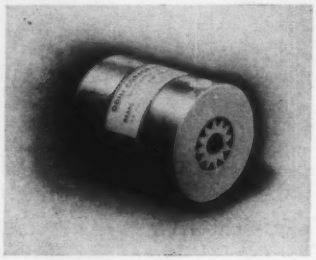
rated current. It operates in temperatures from −65 to 400 F. Symmetrically designed armature permits large lateral accelerations without effect on armature position. Counterbalances can be added if linkage balance is desired. Utilization of two coils provides either series or push-pull operation. Unit is particularly suited for applications requiring a high-response, high-force transducer. **West Coast Div., Cadillac Gage Co.**, P. O. Box 546, Costa Mesa, Calif. L

Circle 708 on Page 19

Shaft Coupling

for diameters from ¼ to 3 in.

New torque-disconnecting shaft coupling disconnects accurately at a predetermined torque figure. Large or small adjustments in torque setting can be made readily, and



resetting after disconnection is simple. Unit permits small shaft misalignment, but also has considerable torsional flexibility. Larger sizes have a central floating member connecting two splined shaft hubs at ends, and smaller sizes combine the floating member with one of the shaft hubs. Couplings are available for diameters from ¼ to 3 in. **Odin Corp.**, Castleton, Ind. J

Circle 709 on Page 19

Transistorized Counter

counts at speeds to 30,000 per minute

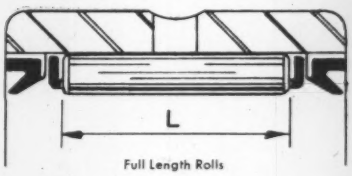
Model N-1 Count-Pak is a transistorized electronic counting package utilizing a compact, glow-transfer, cold-cathode counting tube, a high-speed magnetic counter, and a small, adaptable photohead. Unit counts accurately at speeds to 30,000 counts per minute, and resets at rated speeds without losing counts. Photohead can be as-

Circle 539 on Page 19

More Load Capacity! More Design Flexibility!

ORANGE SEALED *Cage Type* NEEDLE BEARINGS

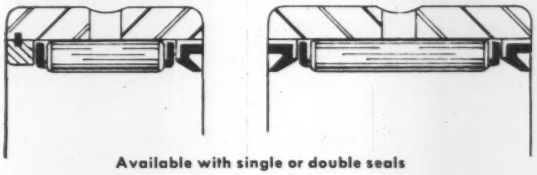
Longer Rolls—Higher Capacity



Full Length Rolls

Only Orange construction provides effective sealing without reducing roll length or load carrying capacity. Note the proportion of roll length to race, compared with other types. You get the full load capacity of Orange Cage Type Needle Bearings—plus the economy and efficiency of built-in Neoprene seals to keep dirt out and lubricant in.

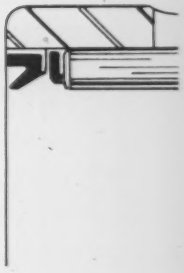
TWO Bearing Lengths for Design Flexibility



Available with single or double seals

Only Orange offers Sealed Cage Type Needle Bearings in TWO bearing lengths for each shaft diameter. Both bearing lengths have full-length rolls in proper proportion to race, providing maximum load-carrying capacity. Thus, you have greater flexibility in meeting load, space and design requirements. Other sealed needle bearings offer only one bearing length, with shorter rolls and less capacity.

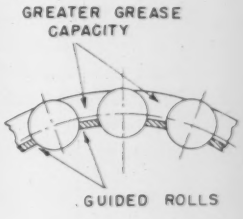
Effective Seal Design →



This provides positive exclusion of foreign matter, retains lubricant and acts as a vent to prevent displacement of seal if additional lubrication is added through holes provided in races.

—plus advantages of Orange Cage Design

The Orange cage design assures constant contact with entire length of roll periphery to provide the ultimate in guided rolls and resistance to skewing. Adequate space around rolls provides exceptional capacity for lubrication.



Stocked in popular sizes from ½" to 2" shaft diameters. Other sizes will be added as volume requirements are established.

Write for engineering data and prices. Ask for 40-page Engineering Reference Manual showing all Orange Roller Bearings.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

Don't overlook the power of the worm!

H&S

WORM-GEAR SETS

insure smooth driving action between perfectly mated members

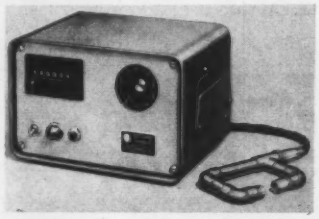
Check these important advantages for your power transmission needs:

Smoothness of Operation • Ability to Carry Heavy Shock Loads
Compactness • Large Ratios • Reliability
Long Service Life • Self-Locking

Horsburgh and Scott worm-gear generating methods guarantee perfect mates in each set, with worm threads and gear teeth having identical pressure angles and tooth contours. Resultant smooth conjugate action delivers maximum right angle power transmission with minimum power loss. H&S gives each set a controlled inspection on the correct center distance for tooth contact, backlash and smoothness.

To meet your requirements H&S makes Worm Gears up to 60 inches diameter—circular pitch range from ¼" to 3½". Ratios can be furnished from 3-5/9:1 to 100:1 . . . For prompt response from H&S engineers, just send an outline of your needs.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio



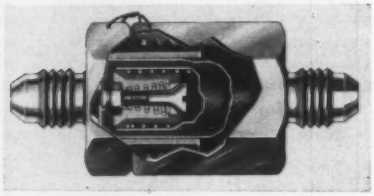
sembled in configurations to meet requirements of any application. Unit is used to measure accurate lengths, to count high-speed shaft revolutions, and to count objects. **Veeder-Root Inc.**, Hartford 2, Conn. B

Circle 710 on Page 19

Filter

for ambient temperatures from −65 to 350 F

New 45-micron filter is designed for high pressures and high temperatures. Operating pressure is 1000 psi, and filter can be designed for pressures to 4000 psi. All components are suitable for high-temperature exposure, unit being designed for ambient temperatures from −65 to 350 F and −65 to



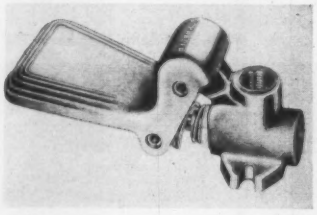
250 F fuel. Filter weighs 0.17 lb in aluminum and 0.42 lb in stainless steel. **Aero Supply Mfg. Co. Inc.**, Corry, Pa. F

Circle 711 on Page 19

Poppet-Type Valves

are actuated by foot pedal

New two and three-way poppet-type valves are actuated by foot pedal with only a light action. Spring action closes valves on release of pedal. No. 3476 two-way valve,

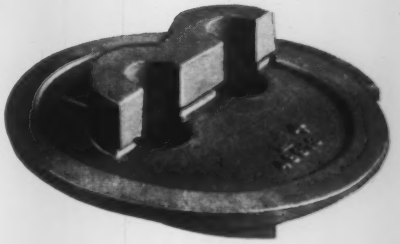


Circle 541 on Page 19

THE DODGE STEEL Ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to design better steel castings

Here are a few tips on how you can obtain better steel castings through improved specification practices and design techniques. By observing these basic suggestions, you can design steel castings that meet strict service requirements, and save time and money, too!



A SOUND APPROACH

Where steel castings are concerned, efficient design goes well beyond merely creating a strong, attractive product. Too often, high unit costs, wasteful rejects, and time-consuming machining problems are designed into a steel casting *before* it reaches the foundry! Here's how to avoid some of these costly pitfalls:

It is important to establish specific service conditions for the casting. And, an accurate determination of critical requirements may make all the difference in the degree of quality as well as economy you achieve.

Unnecessary close dimensional tolerances in your design and undue variation of metal thickness will result in increased labor and material costs. If possible, contact your foundry when reducing the quantity of metal in your casting or when you have a complicated design. Sometimes thin metal sections and complexity is costly.

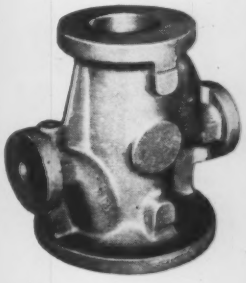
SELECT THE METAL

Before making your final design, it is wise to make a tentative choice of the steel to be used. A design adequate for one type of steel can cause trouble for another. The properties of steels—ranging from low-carbon varieties to high-alloy steels—vary widely in toughness, durability, and ductility, as well as in machining and weldability.

Accurate evaluation of service conditions can improve your choice. Steel castings are usually supplied normalized and drawn. Quenching, tempering, and hardening produce a broad range of properties which are best considered before making your final selection. Once the proper steel is chosen, a design tailored to its particular characteristics will often simplify foundry techniques.

IMPORTANT POINT

Discussing your proposed design with your foundry is highly important where costs are concerned. It's a rare case where suggestions can't be made that will simplify foundry practice and cut down on labor or material. We will be happy to have a Dodge Steel Casting Engineer discuss your design problems with you without obligation.



Send for NEW

DODGE PRODUCTS BULLETIN

This new 8-page Dodge Products Division bulletin is a "must" for those interested in securing the services of a complete manufacturing organization. It tells you how you can benefit by the research, development, and manufacturing facilities of this specialized division of Dodge Steel Company. The diverse engineering and production services—*from idea to finished product*—are described. Typical products, ranging from small machined, heat-treated components to large and complex special equipment, are shown.

Among the numerous facilities covered are milling and drilling, turning, testing and drafting, boring, welding, additive finishes, jigs and fixtures, etc. Send for your *free copy* today! Ask for Bulletin 658.

Circle 542 on Page 19 ▲

Circle 543 on Page 19 ▲

Model "SFD" Flange Mounted Reducer

NEW DOUBLE REDUCTION HOLLOW SHAFT worm gear speed reducers!

Model "STD" Torque Arm Reducer

- **THE COMPLETE** range of reduction ratios — 66⅔:1 to 4466:1.
- **THE COMPLETE** output selection — .04 to 2.55 HP. Torques from 1473 to 7678 in. lbs.
- **SHAFT-MOUNTED** ease of installation. Real space economy. No foundations required.
- **THE SAME RUGGED DURABILITY** and smooth, efficient operation for which Winsmith worm gear speed reducers have long been famous.
- **THIS COMPLETE** selection in choice of several assemblies.

WRITE TODAY for details on this new line which combines all the advantages of hollow shaft installation with worm gear, double reduction ratios engineered and precision-manufactured for you by Winsmith.

WINSMITH SPEED REDUCERS

WINSMITH, INC.
16 Elton Street, Springville, (Erie County), N. Y.

Circle 544 on Page 19

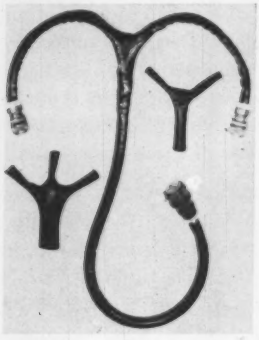
with air-flow capacity of 75 cu ft, has ⅜ in. NPT parts, and is designed for use where limited space is a factor. No. 3477 three-way valve also has air-flow capacity of 75 cu ft. Valves resist vibration, shock, and other abuses. **A. Schrader's Son Div., Scovill Mfg. Co.**, 470 Vanderbilt Ave., Brooklyn, N. Y. C

Circle 712 on Page 19

Zippered Tubing

is available in Y and T configurations

Zippered Y and T configurations permit instant construction of complete waterproof cable-assembly branch-outs. Tubing is wrapped around wire bundle and zipped shut. At the point of a branch-out, wires are split into various channels and a Y or T section is zipped



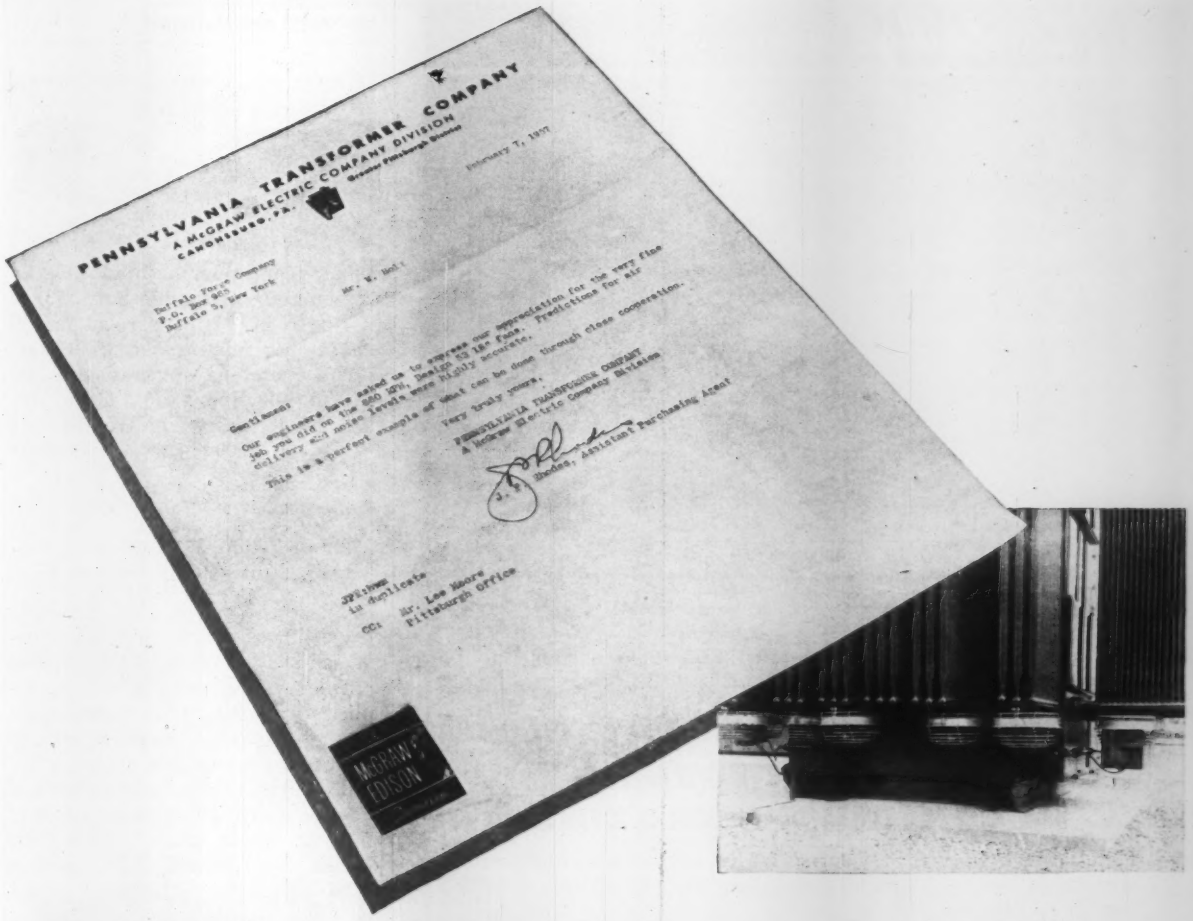
around them. Junction of T or Y to rest of cable is accomplished with high-temperature tapes or potting compounds. When potting method is used, Y or T serves as a flexible mold and compound is poured inside. The new configurations are available in various materials and colors to correspond with tubing used to cover rest of cable. They are furnished in IDs from ½ in. up, in increments of ⅛ in. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles 14, Calif. L

Circle 713 on Page 19

Pump and Motor Unit

operates from 12-v battery

Model AKX Powermite pump and motor combination operates from a conventional 12-v battery. Unit incorporates a ⅛-hp motor into a


PENNSYLVANIA TRANSFORMER COMPANY
A McGRAW ELECTRIC COMPANY DIVISION
CANONSBURG, PA.
Greater Pittsburgh Division
January 7, 1957
Buffalo Forge Company
P.O. Box 965
Buffalo 5, New York
Attn: W. Holt
Gentlemen:
Our engineers have asked us to express our appreciation for the very fine job you did on the 850 HP, Design 15 18½ fans. Predictions for air delivery and noise levels were highly accurate.
This is a perfect example of what can be done through close cooperation.
Very truly yours,
PENNSYLVANIA TRANSFORMER COMPANY
A McGraw Electric Company Division
J. S. Rhodes, Assistant Purchasing Agent
JSR:hwr
Lt duplicate
cc: Mr. Lee Moore
Pittsburgh Office
McGRAW EDISON

ACCURATE FAN PERFORMANCE IS NO ACCIDENT!

The above comments typify the satisfaction received by users of "Buffalo" Air Moving Equipment. They point to the outstanding job performed by the "Buffalo" Fans on this installation. Of equal importance, it also speaks highly of the acknowledged ability of "Buffalo" Engineers to make sure that the fans they recommend will do the job they're required to do . . . and do this job better than any other fan.

Multiple-unit installations of "Buffalo" Fans have been specially-engineered to perform the exacting job of quietly cooling Pennsylvania Transformers to insure reliable and uninterrupted service. Pictured is a typical installation at the Long Island Lighting Company, Hicksville, New York.

Flexible and versatile, these dependable fans are quietly and efficiently ventilating equipment of all types, and plant areas ranging from a single room to large buildings. They provide economical, compact, easy-to-install packaged units in capacities from 500 to 250,000 cfm.

Think of "Buffalo" Fans in terms of the jobs they can be doing *better . . . at lower cost . . .* for you. Investigate them *now*. Contact your nearest "Buffalo" Engineering Representative.

"Buffalo" Fans feature the famous "Q" Factor — the built-in Quality that means trouble-free satisfaction and long life.

"Buffalo"

BUFFALO FORGE COMPANY

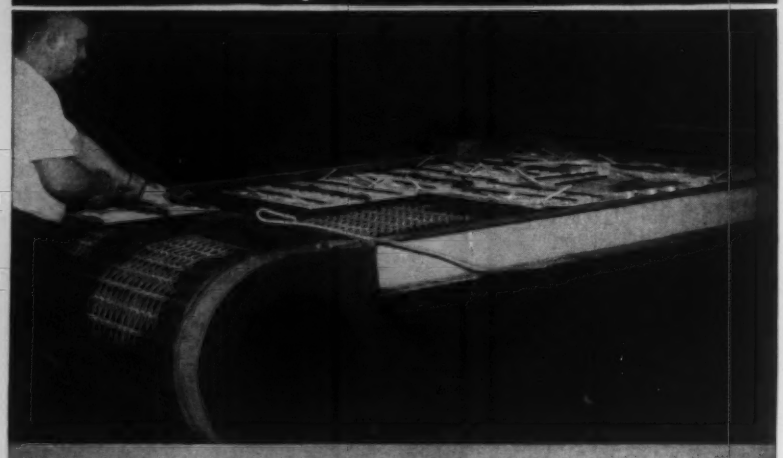
BUFFALO, NEW YORK

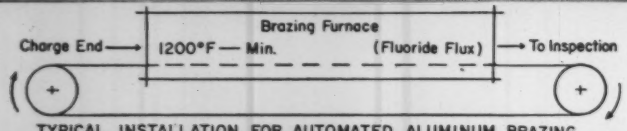
Canadian Blower & Forge Co., Ltd. • Kitchener, Ont.

VENTILATING • COOLING • HEATING • AIR TEMPERING • PRESSURE BLOWING • EXHAUSTING • FORCED DRAFT • INDUCED DRAFT • AIR CLEANING

Circle 545 on Page 19

Cambridge WOVEN WIRE BELTS





TYPICAL INSTALLATION FOR AUTOMATED ALUMINUM BRAZING

METAL-MESH BELT CONTROLS PRODUCT UNIFORMITY IN CONTINUOUS BRAZING

Here's a belt that not only shrugs off hot atmospheres and corrosive fluxes, but helps process metal parts more uniformly—and in less time. Moving continuously through the furnace, the Cambridge Belt allows heat to circulate freely through its open mesh and around the product for thorough treatment.

Glass, chemicals and foods, too . . . can be processed through wet, dry, hot or cold operations on Cambridge Belts to give increased production at lower operating costs. Here's how:

CONTINUOUSLY MOVING BELTS ELIMINATE BATCH PROCESSING—give faster, more economical production; reduce manual handling.

ALL-METAL CONSTRUCTION IS HEATPROOF, COLDPROOF, ACIDPROOF—Cambridge belts can be woven from any metal or alloy to take sub-zero or up to 2100° F. temperatures, yet remain impervious to corrosive atmospheres or solutions.

OPEN MESH PROVIDES FREE AIR, LIQUID CIRCULATION—gives more uniform processing of product; grit, sand, quench solutions drain through belt immediately.

SPECIAL SURFACE ATTACHMENTS AVAILABLE—raised edges or cross flights hold product on belt during movement.

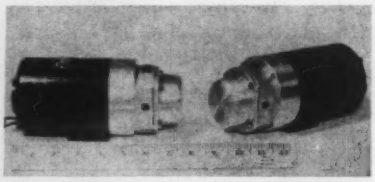
Whether you design machinery for your own use or for resale, your Cambridge Field Engineer can explain how the many advantages of Cambridge Belts make continuous processing practical and economical. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your needs. He's listed in the classified phone book under "BELTING, MECHANICAL." Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department N, Cambridge 9, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES



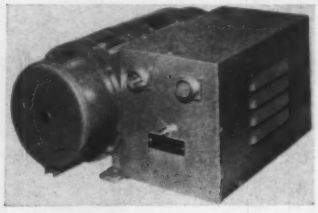
rotary-gear pump, producing a combination measuring only 3-3/16 x 7-5/16 in. Unit is rated for 30 cu in. per min at 500 psi. Maximum operating temperature is 200 F. **Tuthill Pump Co.**, Dept. RP, 953 E. 95th St., Chicago, Ill. J

Circle 714 on Page 19

Inverter

for operation in ambient temperatures from −55 to 55 C

New industrial-type, 28-v dc to 400-cycle inverter was originally designed for ground support of guided missiles in transport. It can be applied to all applications where an inverter of excellent dependability is required. Unit utilizes a battery input of 20 to 30 v dc, or any standard 28-v dc source. It yields an output of 687 va, single phase, 115 v, 400 cycles. Two-bearing unit operates



in an ambient of −55 to 55 C. Integrally mounted regulator limits frequency and voltage to within 1½ per cent of their rated values. **Louis Allis Co.**, 427 E. Stewart St., Milwaukee 1, Wis. K

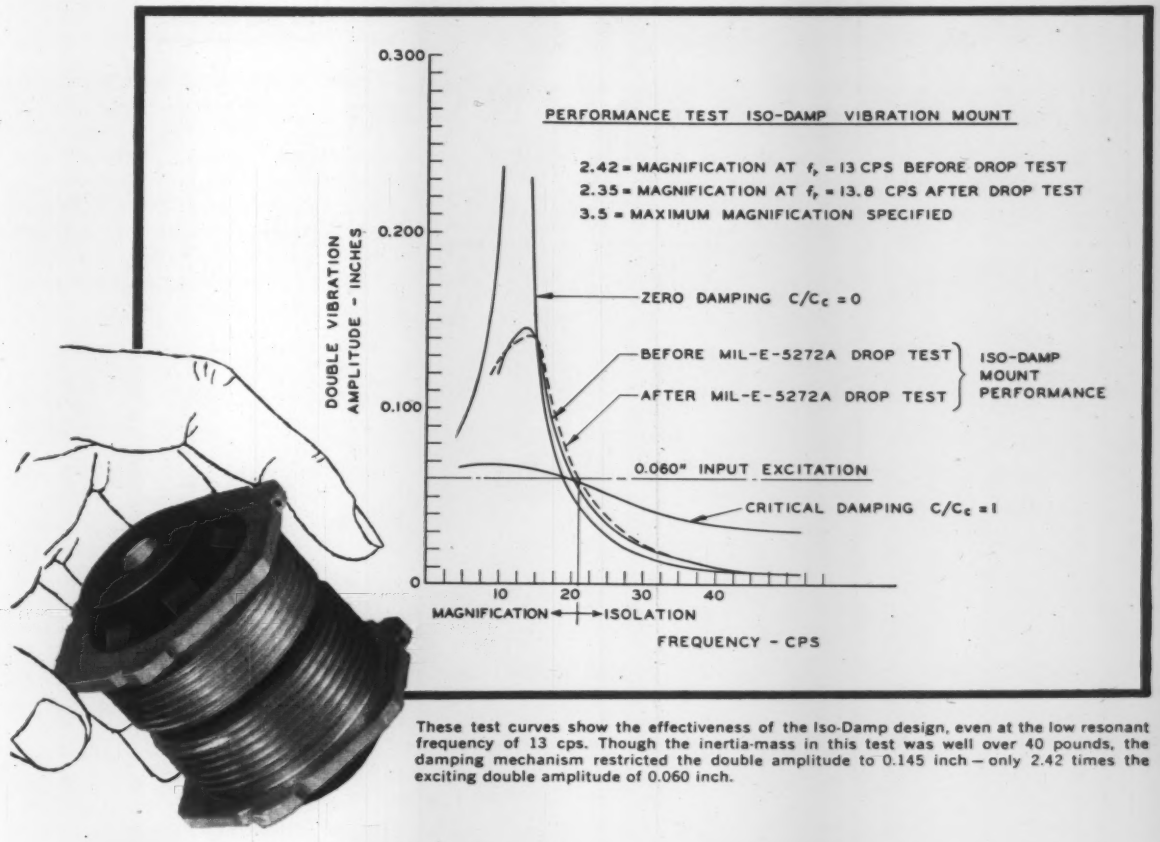
Circle 715 on Page 19

Relays

incorporate new armature design

Two new electrical relays, suitable for a variety of nonmilitary applications, incorporate a "crimp" to the armature, enabling reduction in relay gap and permitting increased miniaturization. First relay is a general-purpose, vertical-coil type which can be mounted in a 1½ sq in. space. Coil rating is 115 v ac, continuous duty, 50 to 60

Circle 546 on Page 19



These test curves show the effectiveness of the Iso-Damp design, even at the low resonant frequency of 13 cps. Though the inertia-mass in this test was well over 40 pounds, the damping mechanism restricted the double amplitude to 0.145 inch — only 2.42 times the exciting double amplitude of 0.060 inch.

MB Iso-Damp™ mounts give full frequency vibration control

A MOUNT soft enough to isolate vibration in the upper range of operating frequencies generally gives trouble when there's a low natural frequency present. It causes resonant build-up... magnifies the motion, as shown by the curve above. Not so the MB Iso-Damp mount. It works at *both* ends of the frequency spectrum... and in any position.

Resilient rubber sections with equal spring rates in all directions (an original MB mount principle) give high frequency isolation efficiency in any position. In the low range, resonance is restricted by a unique damping mechanism to well below a 3½ to 1 build-up. The mechanism does not affect high frequency isolation.

Iso-Damp mounts can be modified to special equipment requirements. They're available in a number of sizes, in threaded or press-in types. When assembled, the damping mechanism is totally enclosed and protected. Load capacities range from 15 to 100 pounds per mount.

MB concentrates on standard mounts which are actually in the *special performance* class. If you have a problem, lean on our 20 years of vibration experience. Send for Bulletin 616A which tells more.

MB manufacturing company
A Division of Textron Inc.
1056 State Street
New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO ISOLATE VIBRATION...TO EXCITE IT...TO MEASURE IT.

Circle 547 on Page 19

ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by

C. Hotchkiss, Jr.

Application Engineer

Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative-motion

2—eliminates exposed revolving parts

3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼-inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1

Relative Motion — Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾-inch Stow flexible shaft driving an Avery Bake built by the Minneapolis Moline Co.

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

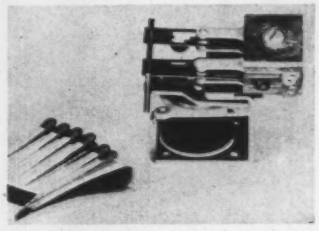
Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛-inch to 1¼-inches; for remote control applications in diameter sizes from ⅛-inch to 1⅝-inches. The 1¼-inch power drive shaft will transmit up to 10 HP while the 1⅝-inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering bulletin 570.

STOW MANUFACTURING COMPANY

11 SHEAR STREET • BINGHAMTON, NEW YORK

cycles; it can be adapted to almost any ac or dc voltage range. Relay is available in single to four-pole circuit arrangement and in any combination. Pull-in voltage is rated at 90 v max. Second unit, a power relay (shown) has contacts rated at 15 amp, ½ hp, 115 v ac, ½ hp. Circuit arrangement is single pole, double throw. Switch



is snap action, producing shortened traverse time and increased contact pressure. **Acro Div., Robertshaw-Fulton Controls Co.**, 2040 E. Main St., Columbus 16, Ohio. G

Circle 716 on Page 19

Vinyl-Encased Foam

for use as seals and vibration dampeners

Foamedge is polyurethane foam encased in vinyl tubing, available as seals and vibration dampeners for various industrial uses. It is soft and flexible, compressing to a fraction of its diameter but with full recovery when released. It combines features of heat insulation and shock absorption. Material is available in any length, with diameters from ¼ to ¾ in. Foam is black or white, and vinyl casing is white or gray. Material is self-adhesive and adheres to clean metal, wood, glass, and most plastics. Strips are cut to length and mounted on cards to facilitate fast handling; material is also available in reels. **Sterling Alderfer Co.**, 3850 Granger Rd., Akron 13, Ohio. F

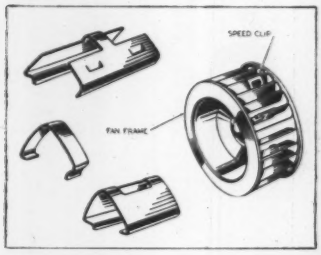
Circle 717 on Page 19

Spring-Steel Fasteners

for dynamic balancing of fan-blower wheels

New spring-steel Speed Clips, available in 3.5, 7, 14, and 28-grain weights, are designed for dynamic balancing of fan-blower wheels. They are snapped by hand over fan

Circle 548 on Page 19



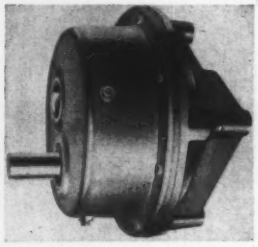
blades where they retain themselves under live spring tension. They do not jar or vibrate loose, but can be removed and repositioned easily. Clips are exactly measured weights which allow complete accuracy in balancing the wheels, in order to lessen wear and increase efficiency. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland, Ohio. F

Circle 718 on Page 19

Flange-Mounted Drive

for horizontal or vertical applications

New gear drive bolts directly to the driven machine. It is designed with bearing capacities for overhung and thrust loads to allow installation into driven machine as a geared pillow block. Built to AGMA recommendations, drive is available for horizontal or vertical



applications, with high-speed shaft up or down. It is available in single reduction for applications of ½ to 10 hp, and in two double-reduction ratios for ½ to 5 hp. **Falk Corp.**, Dept. 255, 3001 W. Canal St., Milwaukee 1, Wis. K

Circle 719 on Page 19

Air-Line Controls

for flows of 5 to 50 cfm and pressures to 125 psi

Tri-Duty air-line controls provide clean, dry, well-regulated, and properly lubricated air for use on all air-operated equipment such as

(*Please turn to Page 230*)

BALDOR

Streamcooled MOTORS

BALTRIC LINE

For general use or for specific applications demanding the most exacting requirements, the Baltric line of motors more than fills the bill. One reason is the "Monocast" Stator shown above.

Steel laminations in an aluminum alloy casting form a stator frame of greater stability . . . greater rigidity. This permits the use of a new and better slot design. The result is uniform magnetic flux distribution throughout the motor—gives more power, greater efficiency, higher power factor and quieter operation.

If you're interested in getting top efficiency from your equipment while holding costs to a minimum, investigate the Baltric line of motors—without obligation! Just write . . .

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Over 500 Authorized Sales & Service Distributors in U. S. A.

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Circle 549 on Page 19

A Report on the

Ten basic attributes that can help you satisfy both design and production needs.

The properties of copper alloys are a handbook in themselves. No group of metals is more versatile. Here are electrical, thermal, structural, chemical and finish properties that are unique. Here are metals that can be shaped and joined by almost every known method.

There are over 40 standard alloys of copper. And each has its own set of specifications, its own combination of properties. Finding the one that best matches *your* specifications is the problem. And the answers to that problem keep changing. Copper industry research into new alloys and new forming and preforming methods gives designers a latitude today that challenges both their imagination and their ability to keep posted. Today we must assume that some copper alloy *can* do the job.

Here are just ten of the more important design requirements that point to the selection of a copper alloy:

1.

Electrical Conductivity. The various types of commercially pure copper have long been the most economic conductors. Now, copper-chromium and copper-cadmium alloys have improved mechanical properties along with high conductivity. And silver-bearing coppers with as good conductivity as commercially pure copper have a higher softening temperature for certain applications involving high temperatures.

2.

Thermal Conductivity. Since many of the low-zinc brasses, as well as copper itself, offer outstanding heat transfer rates, selection usually depends on the other properties desired — corrosion resistance, hot strength, ductility, etc.

3.

Corrosion Resistance. Every corrosion problem is different — and there's a copper alloy to meet most: for chemical applications, heat exchangers, processing equipment, refrigeration apparatus, etc.

4.

Strength. The high-zinc brasses, nickel silvers, beryllium copper, the silicon bronzes and the phosphor bronzes can be processed to provide tensile strengths of the order of 140,000 psi for hard-drawn wire.

Copper Metals

5.

Ductility. The ductility of most copper alloys permits forming them into a wide variety of shapes and sizes, by spinning, stamping, deep-drawing, etc. For example, the coppers, most brasses and nickel silvers are ideal for cold forming.

6.

Malleability. Pure copper and many of its alloys have excellent malleability for forging, cold heading, coining, embossing, extruding, knurling, swaging, etc.

7.

Machinability. Free-Cutting Brass, tellurium copper, some of the bronzes and the leaded brasses are readily machinable at high speeds and feeds.

8.

Joining Qualities. Copper and most copper alloys can be easily soldered — or, for even stronger joints, brazed with either silver alloys or copper phosphorus alloy. The non-leaded brasses, phosphor bronzes, silicon bronzes and cupro-nickels as well as deoxidized copper also lend themselves readily to welding by a number of processes.

9.

Surface Qualities. The nickel silvers and low-zinc brasses are widely used in ornamental applications because of their ease of plating and finishing as well as their cold-working properties. New fine-grain brasses offer an ideal surface structure for high finish.

10.

Casting Facility. There are eight basic categories of casting alloys, ranging from the hard, but very strong, manganese bronzes to the free-machining leaded bronzes.

The combination of properties that you need for the best product and the optimum manufacturing cost can probably be found among the copper metals. The copper industry will help you find it. The Copper & Brass Research Association, 420 Lexington Avenue, New York 17, New York, will welcome your inquiry.

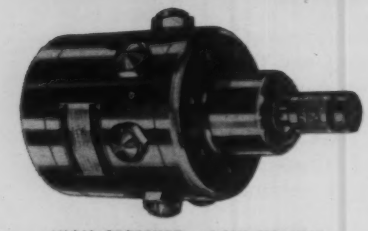
There's a new frontier in...

COPPER
BRASS
BRONZE

Circle 550 on Page 19

RACINE
SECO
Hydraulic Pumps
OFFER MAXIMUM PERFORMANCE AND ADAPTABILITY

features
VANE TYPE PUMPS
★ 5 to 70 gpm — up to 1000 psi
★ Variable volume for reduced horsepower consumption
★ Maintain pressure without costly waste of by-passing oil
★ Variety of governors available to suit your requirements



HIGH PRESSURE — LOW VOLUME
Model LA Radial Piston Pump
½ to 20 gpm — up to 10,000 psi.

RADIAL PISTON PUMPS
★ ½ to 20 gpm — up to 10,000 psi
★ ISO-FLO design for several isolated flows from *one* pump
★ Isolated flows at one pressure or several pressures
★ Ideal for accumulator circuits and parallel feed of cylinders

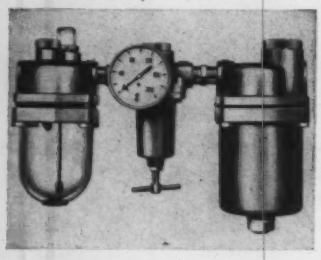
TAILORED TO FIT THE JOB . . .
ONE SOURCE —
ONE RESPONSIBILITY
Utilize our FREE Engineering Service for the most efficient and economical circuit. Write or call for complete descriptive data on RACINE-SECO Hydraulic Pumps and circuit components.

Racine Hydraulics & Machinery, Inc.
2073 Albert Street RACINE, WISCONSIN

Circle 551 on Page 19

(Continued from Page 227)

air tools, cylinders, motors, clutches, and chucks. Package consists of an air-line lubricator, water separator, and air regulator. Controls operate most efficiently with minimum of pressure drop at flows of 5 to 50 cfm and pressures to 125 psi. Lubricator has a self-compensating valve which eliminates need for



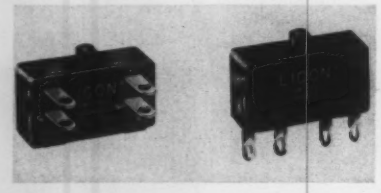
manual adjustment to accommodate varying air pressures and volumes. It handles all air-line pressures to 200 psi and a wide range of oil in all viscosities to 500 SSU at 100 F. **Alemite Div., Stewart-Warner Corp.**, 1826 Diversey Parkway, Chicago 14, Ill. J

Circle 720 on Page 19

Subminiature Switch

incorporates double-break contacts

Type 16 subminiature switch is available in three terminal styles with a variety of actuators, and in a reset model with side or end terminals. Switch, measuring only 1/4 x 7/16 x 25/32 in., incorporates double-break contacts which



permit extra circuit variations. Unit carries 10 amp at 30 v dc inductive. **Licon Switch & Control Div., Illinois Tool Works**, 2501 N. Keeler Ave., Chicago 39, Ill. J

Circle 721 on Page 19

Magnetic Disc Brakes

for C-flange motor or foot mounting

Magnetic disc brakes, rated 125 through 575 lb-ft torque, are de-

Want industry's most versatile heat source?

Your Chromalox Man has the Answer

Chromalox Electric Strip Heaters provide uniform, precise heat to fit the size and shape of your production equipment. For heating platens, dies, kettles, tanks, pipes, ovens, air ducts . . . there's a Chromalox Electric Strip Heater to provide the many advantages obtained only with electric heat. Low initial cost; quick, easy installation with standard bolts or clamps; long, maintenance-free heater life at low operating cost. Instant heat-up. Accurately maintained temperatures on each machine, by either automatic or manual control.

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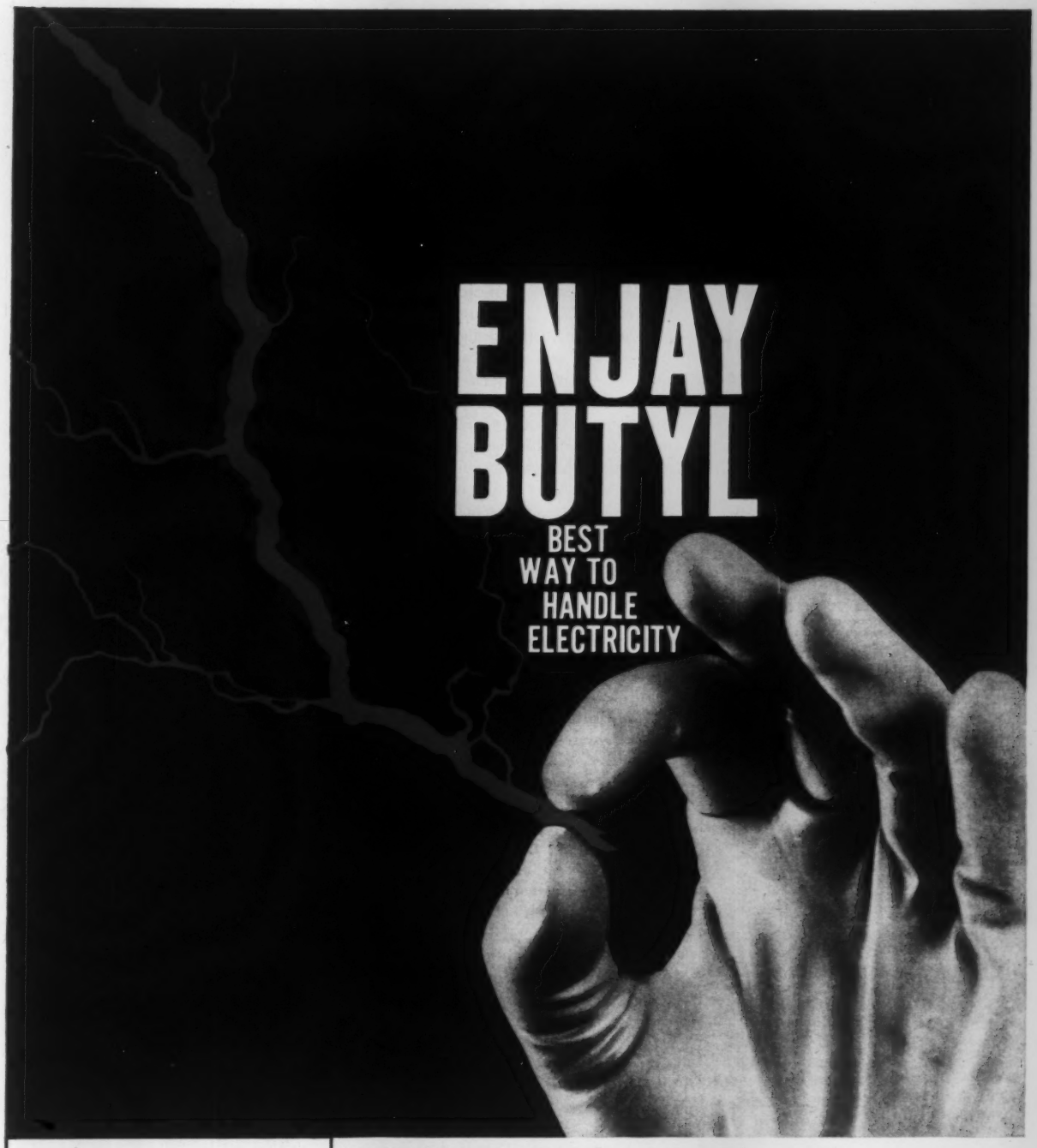
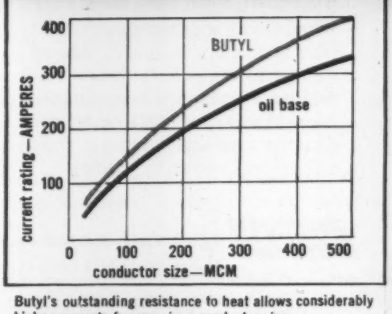
Circle 552 on Page 19





Butyl's outstanding resistance to heat allows considerably higher currents for any given conductor size.

Of all vulcanizable rubbers, Enjay Butyl offers the best electrical and dielectric properties. Butyl is the ideal material for wire and power cable, transformers, tapes, busbars and other insulation applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . abrasion, tear and flexing . . . superior damping properties . . . unmatched impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

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ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Circle 553 on Page 19

STANPAT SOLVES THE GHOSTING PROBLEM

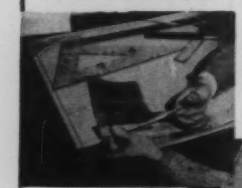
NEW resin-base STANPAT ELIMINATES GHOSTING, offers better adhesion qualities on specific drafting papers!

THE PROBLEM
Some of our longtime customers first called our attention to the "ghosting" problem. Certain tracing papers contain an oil which could be leeched out by the STANPAT adhesive (green back) causing a ghost.

THE SOLUTION
A new STANPAT was developed (red back), utilizing a resin base which did not disturb the oils and eliminates the ghost. However, for many specific drafting papers where there is no ghosting problem, the original (green back) STANPAT is still preferred.

WHICH ONE IS BEST FOR YOU?
Send samples of your drawing paper and we will help you specify. Remember, STANPAT is the remarkable tri-acetate pre-printed with your standard and repetitive blueprint items—designed to save you hundreds of hours of expensive drafting time.

SO SIMPLE TO USE



1. PEEL the tri-acetate adhesive from its backing.

2. PLACE the tri-acetate in position on the tracing.

3. PRESS into position, will not wrinkle or come off.

STANPAT CO.
WHITESTONE 57, N. Y. Dept. 47
Phone: FLushing 9-1693-1611

☐ Enclosed are samples of the drafting paper(s) I use (identify manufacturer). Please specify whether Rubber Base or Resin Base STANPAT is most compatible with these samples.

☐ Send literature and samples of STANPAT.

☐ Please quote price on our enclosed sketches which we are considering to have pre-printed.

NAME_____

FIRM_____

ADDRESS_____

CITY_____

ZONE____ STATE_____

Circle 554 on Page 19

signed for C-flange motor mounting on frames 324U through 505C, or for foot mounting. Designated 90M, brakes are self-adjusting for wear and have high thermal capacity. High thermal capacity suits combination brake-motors for high-inertia loads or high-frequency starts and stops. **Dings Brakes Inc.**, 4740 W. Electric Ave., Milwaukee 46, Wis. K

Circle 722 on Page 19

Teflon Seal

provides positive sealing with low break-out friction

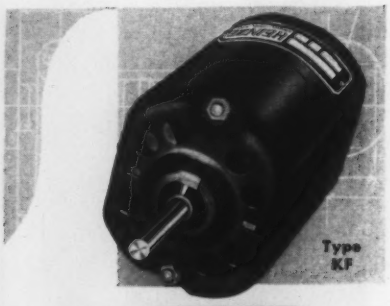
Kapseal is a Teflon boot used in conjunction with a standard O-ring in applications such as guided missiles which have long periods of inactivity. It is also applicable on continuously operating installations. Unit provides positive sealing with low break-out friction, eliminates welding effect noted in simple elastomeric seals after long storage, and gives better sealing without extremely high break-out force found with metal seals. Seal is available in two styles, one (Kin) used in installations where friction surface is applied to ID of seal, and the other (Kex) in installations where OD of seal is the sealing surface. Standard sizes range from 0.125 to 7.750 in. ID for Kin and 0.250 to 7.750 in. OD for Kex. Seal can be used in a wide variety of aircraft and industrial applications. **Minnesota Rubber Co.**, 3630 Wooddale Ave., Minneapolis 16, Minn. J

Circle 723 on Page 19

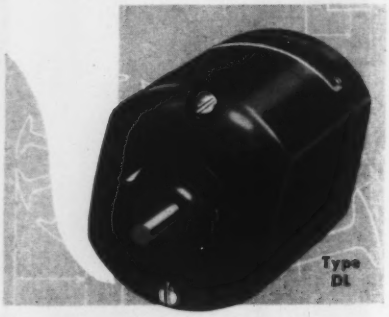
Control Valves

for use in hazardous locations

Speed King ¼-in. four-way control valves are suited for use in hazardous locations and wherever remote



put HEINZE in your designs



VERSATILITY...IN HEINZE UNIVERSAL MOTORS

Variable speed . . . high starting torque . . . reversibility . . . high output . . . you get them all in Heinze Universal Motors. Horsepower ratings are from 1/15 hp to 1/50 hp, with load speeds of 5000 to 7500 rpm. Normally designed for 115V AC/DC, CW, CCW or reversing. Other voltages are available. Internal or external brushes may be supplied. Type DL has die cast housing. Broad applications include sewing machines, business machines, movie projectors, electric organs, small hand tools.

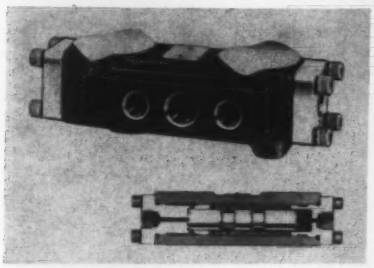
You have a wide choice of models from the comprehensive line of Heinze sub-fractional horsepower motors and blowers. Send us your product and specifications. Heinze Engineers will adapt a motor, at no obligation. Or write for catalog.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.

Sub-Fractional Horsepower Motors and Blowers

Circle 555 on Page 19

pilot operation is desired on pneumatically interlocked circuitry. The foot-mounted, remote-operated valves are furnished in single and double types, with identical port and mounting locations on both types. Cylinder ports and inlet are tapped ¼ in. NPT, and exhaust is tapped ⅜ in. NPT. Single-type valves are designed for 35-250 psi air and oil service. Double types control 35-250 psi air and oil, as



well as vacuum down to 1 in. Hg less than absolute. **Valvair Corp.**, 454 Morgan Ave., Akron 11, Ohio. F

Circle 724 on Page 19

Nuts

for temperatures to 1400 F

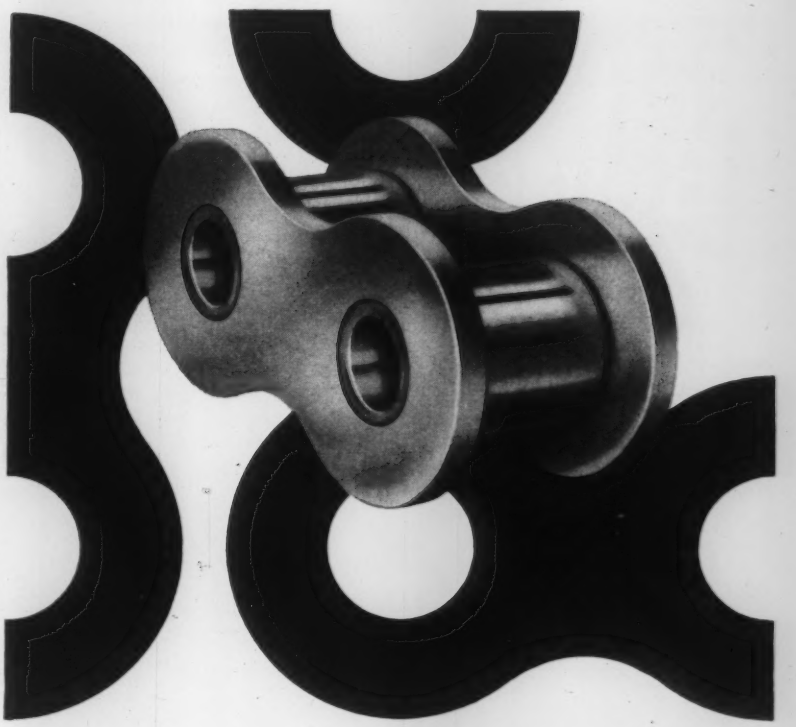
Three styles of aircraft nuts are available in M-252 material for temperatures up to 1400 F. Star Lok incorporates spread-load, hanging thread for high-temperature fatigue resistance. Hexagon Jet Lok utilizes slotted-beam principle in high-beam configurations for standard and 0.003-in. reduced bolts. Life Lok utilizes stress-relieving cutaways at each ellipse apex, providing out-of-round normalization which permits long reusability at high temperatures. **Boots Aircraft Nut Corp.**, 536 Newtown Turnpike, Norwalk, Conn. B

Circle 725 on Page 19

Step Switch

is driven at speeds to 300 steps per min

Heavy-duty MT step switch is available with 2 to 20 independent 10-amp circuits. It is driven by a rotary ac solenoid at speeds to 300 steps per min. Up to 16 steps per cycle are available with each circuit closed for one or more steps, depending upon cam breakouts. Camshaft advances on de-energized return stroke of solenoid. Two frame



GET MORE ENGINEERED EXTRAS

WHITNEY PROCESSED CHAIN FOR BETTER DRIVE DESIGN LONGER SERVICE LIFE

Whitney's *fatigue-resistant* Processed Roller Chain Drives are setting new service records in every field. Important Whitney developments now supply *increased endurance, greater dynamic strength* for the toughest problem drives . . . for special power transmission and conveying requirements.

These developments include:

- **Patented process which imparts beneficial stresses to critical internal surfaces of chain rollers for greater fatigue life. This roller treatment is possible only through the Whitney process.**
- **Unique compressive technique applied to heat treated alloy steel chain links builds in concentrated residual stresses in the pitch hole area for greater dynamic strength.**
- **Shotpeening of components raise endurance limits to accept higher loadings imposed by modern drive demands.**

Your Whitney Factory or Field Service Engineer will gladly explain how these quality cost-saving features can be selectively applied to your present equipment or drive design for maximum performance.

And Whitney's complete line of standard, finished steel chain drives insure adaptability to the widest range of power transmission and conveying requirements. Available through field warehouses and nationwide distributor service. Write for helpful, practical catalog literature.

Heard About Whitney-Tormag Magnetic Drives?

For complete motor overload protection, cushioned starts and high efficiency, ask about our new permanent magnet, self-contained power transfer units. Available in 1, 2, 3 and 5 H.P. units as stock items, additional sizes up to 15 H.P. will follow . . . Write for new 8 page Technical Bulletin. Box 318C-TOR

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ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

Circle 556 on Page 19

Full House!

...a setko self-locking set screw for every problem!

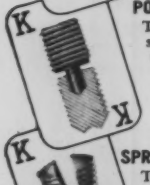
... And, every Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action... speed assembly and cut costs by utilizing standard driving techniques... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").

ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.

OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.



POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

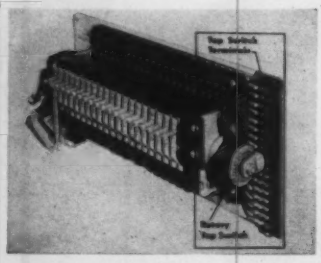
FREE, NEW "SELECTOR CHART" of Self-Locking Set Screws

Illustrates and describes complete range of Setko locking actions, points, metals, combinations, etc. WRITE TODAY... Also ask for our complete catalog No. 21.

Set Screw & Mfg. Co.
28 Main Street, Bartlett [illegible]

1583R

Circle 557 on Page 19



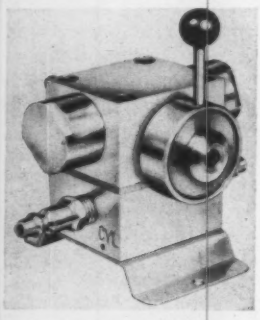
sizes are available, one accommodating 2 to 12 total circuits, and the second, 13 to 20 circuits. Addition of a tap switch accessory increases number of circuits to 36. **Eagle Signal Corp.**, 202 20th St., Moline, Ill. I

Circle 726 on Page 19

Air Valves

are four-way, inching-type units

New four-way air valves will advance the ram of a double-acting air cylinder to any desired point and hold it there without creeping. BL-601 (shown) is equipped with a lever which requires a light push to move 45 deg left or right. One position advances ram and the other retracts it, but stops it instantly in median position. BL-600 operates in a similar fashion, but uses two small limit valves rather than the lever. **Mead Specialties Co.**, Dept. I-25, 4114 N. Knox Ave., Chicago 41, Ill. J



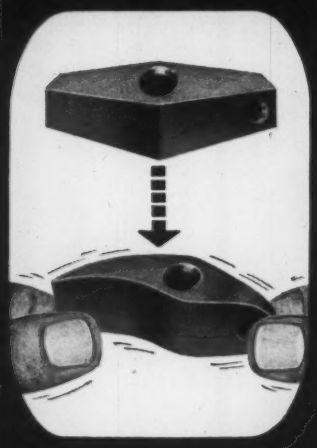
Circle 727 on Page 19

Mercury Switch

miniature unit can be mounted in any position

Miniature mercury switch is available for use in instruments, computers, scales, and electronic devices. Suited for applications where a minimum of operating energy is

just to *stretch* a point.



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INVESTMENT CASTING

Parts design becomes as flexible as wax when you specify Investment Casting. Because with this "lost wax" process, parts can be designed for function; for utmost operating efficiency rather than compromised to satisfy a method of manufacture.

Costly machining and assembly operations are reduced and often eliminated. Complex and time consuming tooling setups too! And — you have the widest selection of alloys from which to choose: the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels... even cobalt base alloys.

Thus you stretch your design potential, you stretch your range of metals and you stretch your budget when you specify this process.

It might stretch your imagination too, if you could see some of the intricate shapes we're casting here at Hitchiner. If you'll write us today for our free new brochure, you'll get an idea how you can utilize the freedom and savings offered with Investment Casting.

For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

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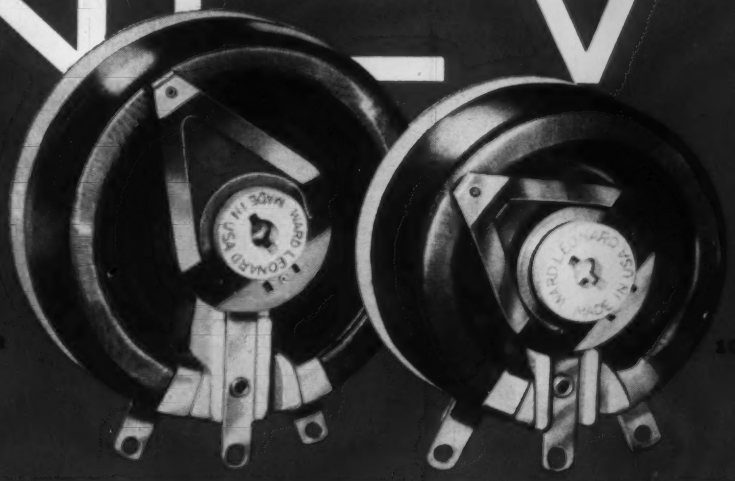
MANUFACTURING COMPANY, INC.
MILFORD 44, NEW HAMPSHIRE
Representatives in Principal Cities

Circle 558 on Page 19

NEW



SMOOTH-PERFORMING RING RHEOSTATS

New 100- and 150-watt sizes incorporate latest design improvements

ENGINEERING DATA

Type	Rating*	Ring Diameter	Max. Depth behind panel	Resistance Range (Stock Values)	Rotational Travel
100R	100 Watts	3 5/32"	1½"	1 to 10,000 ohms	300°
150R	150 Watts	4"	1¾"	1 to 10,000 ohms	314°

*—Ratings based on a 300°C rise in a 40°C ambient.

Contact Shoe: "Twin" metal graphite, equipped with integral copper leaf conductor ribbon riveted to the control arm.

Contact Arm: Balanced beryllium copper, locked directly to insulating hub.

Base and Core: High-grade ceramic of high dielectric strength with toroidally wound resistance wire or ribbon of highest stability.

Max. Voltage Spacings: 300 volts in accordance with Underwriters' Laboratories requirements.

Naturally, these new 100- and 150-watt ring rheostats give you the same outstanding, proved design features you get in 25-, 50-, and 300-watt sizes. Exclusive "twin-contact" shoes insure uniform contact resistance, extra-smooth resistance change. Two sintered, self-lubricating contacts—one on the collector ring and one on the resistance winding—can't gall or seize like metal-to-metal contacts. They insure long, stable operating life under rated loads.

Ward Leonard Vitrohm vitreous enamel permanently bonds base and core, firmly secures the high-stability resistance wire. Base and core are of high-density, low-porosity molded ceramic of high dielectric strength.

A new ceramic hub design substantially eliminates backlash. It also makes for fast delivery on special shaft requirements.

Write for Ward Leonard Bulletin 60RR. It gives complete specifications on 25-, 50-, 100-, 150-, and 300-watt ring rheostats. Ward Leonard Electric Company, 58 South Street, Mount Vernon, New York. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) 65

LIVE BETTER...*Electrically*

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

Built-Experienced Controls Since 1892

Circle 559 on Page 19

DORMEYER SOLENOIDS

Engineered

TO OUTLAST PRODUCT LIFE

MILLIONS OF CYCLES constitute standard DORMEYER dependability. DORMEYER solenoids serving this long *and longer* continue in smooth operation in countless products today.

All types and sizes available to meet your needs. DORMEYER quality means dependable, long-lasting, trouble-free circuit operation...and DORMEYER production facilities mean low unit cost, on-time delivery.

DORMEYER electro-mechanical controls can be custom-engineered to your requirements...depend on our 30 years of specialized experience to solve your problems.

DORMEYER also makes a complete line of coils and transformers.

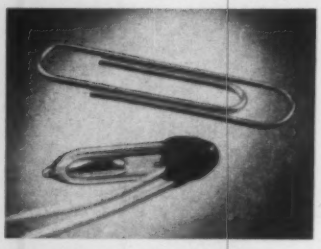
•

Send b/p and specs for recommendations. Request free 20-page data-packed catalog.

DORMEYER INDUSTRIES
FACTORIES IN CHICAGO AND KENTLAND, INDIANA
3434 Milwaukee Ave., Chicago 41, Ill.

Circle 560 on Page 19

available and space is limited, it can be actuated by slow, snap, or fast tilting action. With attached leads, switch weighs only 1.8 grams. Glass tube is hermetically sealed to prevent entry of dirt, dust, moisture, or corrosive gases. Switch can be mounted in any position through 360 deg around its longitudinal



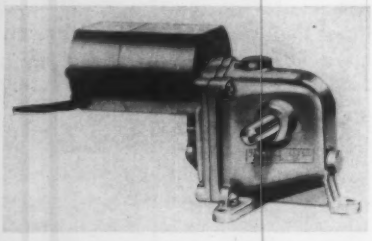
axis. As electrical load increases, differential angle tends to increase. Contact arrangement is single pole, single throw. Position in which switch is mounted determines whether circuit is normally open or normally closed. **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.** K

Circle 728 on Page 19

Gearmotor

has output speeds from 2.8 to 100 rpm

Lightweight, high-torque gearmotor is available in six ratios from 1787:1 to 52:1, producing up to 450 lb-in. torque. Output speeds at full load range from 2.8 to 100 rpm. Unit has universal 1/6, 1/10, or 1/15-



hp motor, wired for instant reversing. **Von Weise Gear Co.,** 9353 Watson Industrial Park, St. Louis 19, Mo. I

Circle 729 on Page 19

Junction Transistor

for low-speed switching applications

No. 2N586 germanium p-n-p alloy junction transistor has maximum body length of 0.375 in. and maxi-

VIGILANCE

The final victory over cancer will come from the research laboratory.

But there is a more immediate victory at hand today. Many cancers can be cured when detected early and treated promptly. *Vigilance* is the key to this victory.

There are certain signs which might mean cancer. Vigilance in heeding these danger signals could mean victory over cancer for you:

1. **Unusual bleeding or discharge.**
2. **A lump or thickening in the breast or elsewhere.**
3. **A sore that does not heal.**
4. **Change in bowel or bladder habits.**
5. **Hoarseness or cough.**
6. **Indigestion or difficulty in swallowing.**
7. **Change in a wart or mole.**

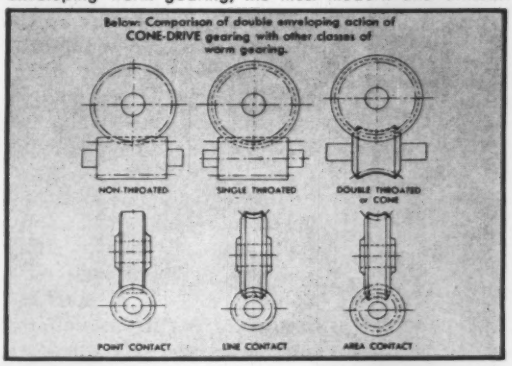
If your signal lasts longer than two weeks, go to your doctor to learn if it means cancer.

AMERICAN CANCER SOCIETY

TEAR OUT AND MAIL IN FOR COMPLETE DATA

How to get the most out of Worm Gearing

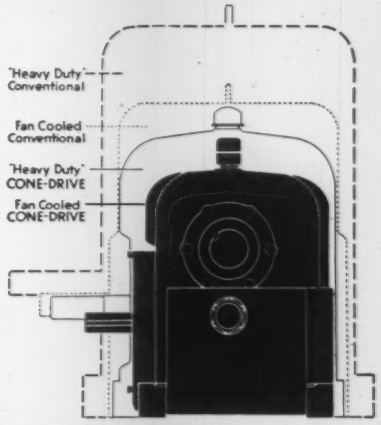
If a right-angle drive is needed in your product and you require maximum capacity for your dollar, then the Cone-Drive double-enveloping type will give it to you. The sketch below shows the apparent advantages of Cone-Drive gearing as compared to other worm gear types. Double-enveloping worm gearing, the most modern and efficient


Below: Comparison of double enveloping action of CONE-DRIVE gearing with other classes of worm gearing.
NON-THROATED
SINGLE THROATED
DOUBLE THROATED or CONE
POINT CONTACT
LINE CONTACT
AREA CONTACT

form, has straight-sided teeth in both worm and gear. Both elements of Cone-Drive are throated and envelop each other, providing a multiple tooth area contact. This means greater load-carrying capacity than is possible with any other type of worm gearing.

Double-enveloping worm gearing is available from Cone-Drive Gears in complete lines of gearsets, speed reducers and gearmotors. Gearsets are stocked in center distances from 2" thru 24", capable of handling loads from fractional to over 1600 horsepower. A complete line of mountings for gearsets is also stocked.

Speed reducers and gearmotors with Cone-Drive double-enveloping worm gearing are unusually compact and powerful drives that handle shock loads with ease. Yet, they provide power transmission smoother than that of hydraulic systems. Another advantage, unique to double-enveloping worm gearing, is their ability to regenerate themselves when wear occurs. Both worm and gear tend to reproduce the correct form in the other when wear occurs.



Double-enveloping worm gearing with its "wrap-around design" requires shorter center distances than cylindrical worm gearing to handle the same loads. As a result, Cone-Drive speed reducers have smaller housings with corresponding savings in weight and space. Bulky gear trains can often be replaced with a single Cone-Drive speed reducer or gearset.

DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road • Detroit 12, Michigan
Telephone: TWinbrook 1-3111

Please send me information on following:

☐ Gearsets ☐ Gearmotors ☐ Speed Reducers

Name_____

Title_____

Company_____

Street_____

City_____ State_____

TEAR OUT AND MAIL IN FOR COMPLETE DATA

TEAR OUT AND MAIL IN FOR COMPLETE DATA

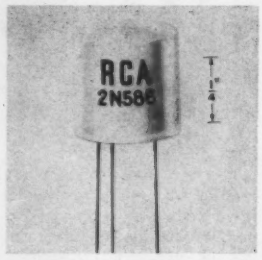
TEAR OUT AND MAIL IN FOR COMPLETE DATA

NEW EAGLE STEP SWITCH offers a special approach to automatic process control step sequencing

Development of the Eagle step switch now provides a new approach to process control. Any type of time or sensing device can be used to advance the switch, and a multiplicity of load circuits can be operated in any combination — up to 19 circuits. Devices used to actuate the switch include: push buttons, limit switches, timer intervals, pressure change components, level control apparatus.

The new switch also provides a sequencing interlock when used with multiple indexing circuits. A mechanical circuit interlock by cam action eliminates interlocking relays. Ten ampere switch contacts control load switches direct — no need for load relays. Switch is built with 115 volt coil, and is of heavy duty industrial switch construction throughout.

Make certain you get complete information on this new switch. Send for Bulletin 780. Eagle Signal Corporation, Dept. MD-958, Moline, Illinois.



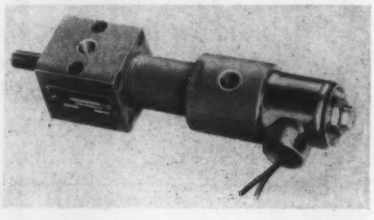
mum diam of 0.360 in. Designed for low-speed switching applications in industrial and military equipment, it is particularly useful as a relay-actuating device and in voltage-regulator, multivibrator, dc-to-dc converter, and power-supply circuits. It can also be used as an audio oscillator and as a large-signal Class A or Class B push-pull audio amplifier. Unit withstands a maximum collector-to-base voltage of − 45 v, maximum collector current of − 250 ma, and maximum collector dissipation of 250 mw. **Semiconductor Div., Radio Corp. of America,** Somerville, N. J. D

Circle 730 on Page 19

Valve-Operated Cylinder

with pressure range to 200 psi

Valve-operated cylinder consists of a conventional single-acting cylinder and new three-way solenoid valve. Integral construction assures instant piston response to the valve with no lag or delay. Optional flow controls can be provided in front cylinder port and solenoid-valve exhaust port for positive control of piston rod speed in either or both directions. Unit can be used as a fixture clamp or with jigs, fixtures, knockouts, and release mechanisms in a wide range of industrial applications. Unit is easily connected into the electrical sequence circuit, and foot, limit, or hand switches can be used. Six bore sizes range from 1 to 3 in., in any stroke length from 1/16 in. up.



Pressure range is zero to 200 psi. Most ac and dc voltages are available. **Airmatic Valve Inc.**, 7313 Associate Ave., Cleveland 9, Ohio. G

Circle 731 on Page 19

Foot Switch

incorporates overtravel stop ring

Redesigned Cadet foot switch is a lightweight, compact unit 3⅝ in. in diam and 1 3/16 in. high. Designed

to operate from any angle to give better control, an overtravel stop ring has been incorporated in the switch. Operator can thus step on switch at any point with any degree of force. Switch has a wide variety of commercial and industrial applications. **Linemaster Switch Corp.**, 432 Woodstock Terrace, Woodstock, Conn. B

Circle 732 on Page 19

Snap-Action Switch

has operating forces from 2 to 20 oz

Series 5300 subminiature snap-action switch is available in regular

or round-base style (shown). Round-base style is particularly adaptable for multiple-switch ganging in confined areas. Switch has a full range of operating forces from 2 to 20 oz. Plastic case has high strength and dimensional stability. Terminals are molded into plastic cover and will not wobble or be loosened under rough usage. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn. B

Circle 733 on Page 19

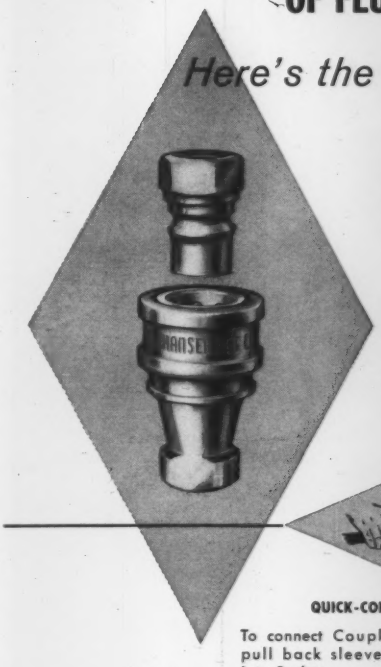
WHEREVER YOU NEED 2-WAY SHUT-OFF OF FLUID LINE CIRCUITS...

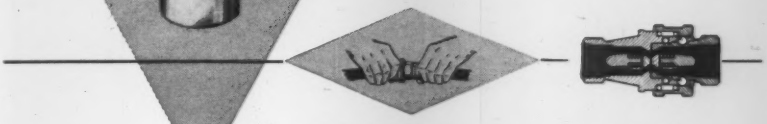
Here's the Coupling for the Job

HANSEN

SERIES HK®

TWO-WAY SHUT-OFF COUPLING

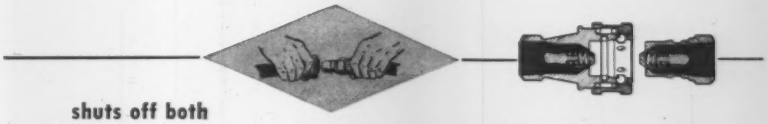




QUICK-CONNECTION with INSTANT AUTOMATIC FLOW

To connect Coupling, merely pull back sleeve, push Plug into Socket.

Blue section shows how torpedo type valves open in both Socket and Plug to permit free flow of gas or liquid through connected Coupling.



shuts off both sides of circuit... prevents loss of liquid, gas, or pressure

QUICK-DISCONNECTION with INSTANT AUTOMATIC SHUT-OFF

To disconnect Coupling, just pull back sleeve on Socket. No tools required.

Blue section shows how torpedo type valves contact valve seats in both Socket and Plug to provide instant seal of fluid on both sides of circuit.

WRITE FOR THE HANSEN CATALOG

Here's an always ready reference when you want information on couplings in a hurry. Lists complete range of sizes of Hansen One-Way Shut-Off, Two-Way Shut-Off, and Straight-Through Couplings—including Special Service Couplings for L. P. Gas, Steam, Oxygen, Acetylene, etc.

To connect a Hansen Two-Way Shut-Off Coupling, you merely pull back the sleeve and push the Plug into the Socket. To disconnect, just pull back the sleeve. No tools required. When Coupling is disconnected, similar valves in Socket and Plug shut off both sides of the fluid line circuit—practically eliminate spilling of liquid or escape of gas at instant of disconnection.

Hansen Series HK Two-Way Shut-Off Couplings are available with female pipe thread connections from ⅛" to 1" inclusive. Available in brass or steel.

SINCE 1915

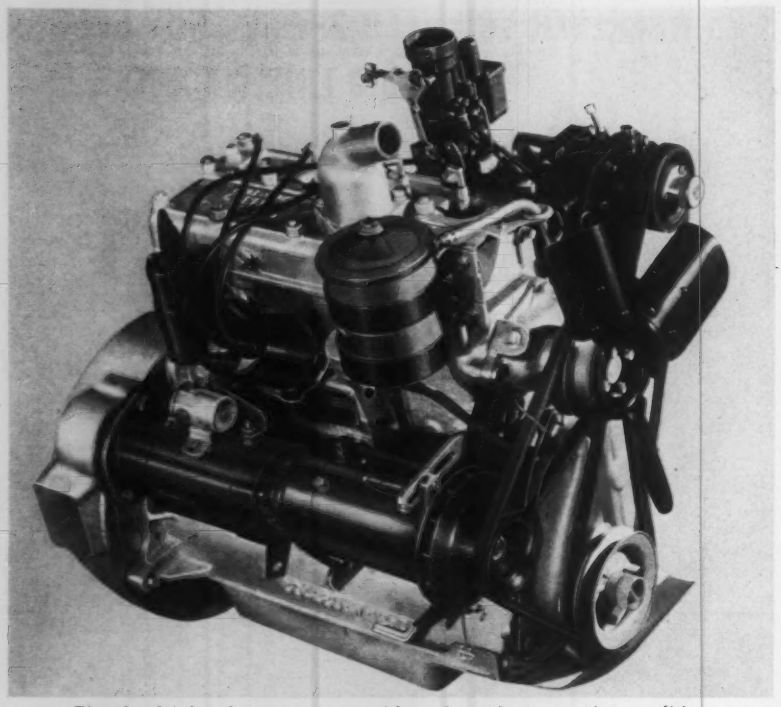
REPRESENTATIVES IN PRINCIPAL CITIES

QUICK-CONNECTIVE FLUID LINE COUPLINGS

THE HANSEN MANUFACTURING COMPANY

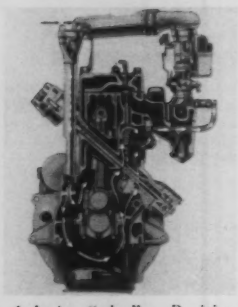
4031 WEST 150th STREET • CLEVELAND 35, OHIO

Circle 563 on Page 19



The 'Jeep'-4 has been proven to withstand toughest operating conditions. It is ideal for continued top performance.

'Jeep'-4 an unique engine design for industrial-agricultural uses!

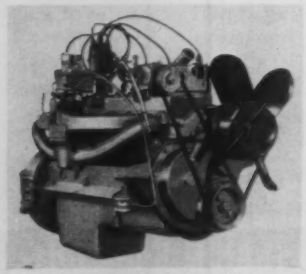


A design "plus"... Positive Crankcase Ventilation forces filtered air through crankcase to remove oil thinning or acid forming condensates.

In its class, only 'Jeep' offers all these long-life features as standard equipment: Positive Valve Rotators, Hard Faced Stellite Valves, Positive Crankcase Ventilation, and many more. L head and F head designs. Write or call for power curves and specifications.

The New 'Jeep'-6

Heavy duty, 6 cylinder engine with new 4 ring piston design . . . valve inserts . . . positive valve rotators. High torque. Send for information.



Economical 'Jeep'-6 is a rugged 226 cu. in. industrial engine.

KAISER WILLYS MOTORS

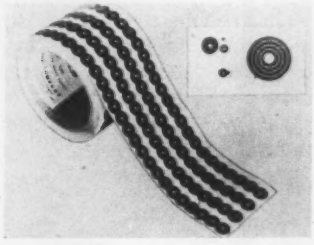
WILLYS MOTORS, INC.
Industrial Engine Dept., Toledo, Ohio

ENGINEERING DEPARTMENT
EQUIPMENT

Drafting Aids

for printed-circuit master drawings

Decimal sizes and new shapes have been added to a line of black or white pressure-sensitive donut pads, teardrops, corners, T-shapes, and narrow tape. New universal corners are nests of four concentric rings from which segments can be cut to provide any desired angle and radius for drawing printed wiring when used with narrow tape of corresponding width. Black pressure-sensitive tape is slit to any fractional or decimal width in 60-yd rolls. For terminal areas, fractional and decimal donut-type pads and teardrop combinations are available. For opposite side of double-face transparent drawings, terminal-area shapes and widths of narrow tape are furnished in pure white. Thus the black taped side is photographed through the transparency against a white background and white taped side against a black background, assuring perfect register of double-side circuit. **By-Buk Co.**, 4314 W. Pico Blvd., Los Angeles 19, Calif. L



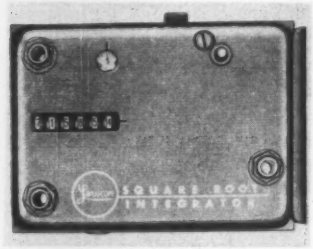
Circle 734 on Page 19

Square-Root Integrator

for use in standard flowmeters

Model 26 square-root integrator, designed for flow-measurement systems, provides a continuous means of automatically totaling flow. For use in standard flowmeters that

Circle 564 on Page 19



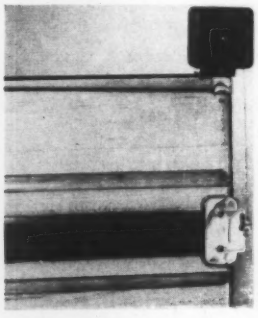
utilize output of conventional sensing elements, unit has wide range of applications, include use as a pressure corrector on positive-displacement meters. It can also be adapted to miniature strip-chart flow recorders, forming an electromechanical integrator. Linearity is 0.25 per cent of full scale, achieved with repeatability of 0.05 per cent of full scale. Maximum recommended input speed of 60 rpm, combined with full-scale ratio between time shaft and counter of 2:1, provides counter with maximum rate of 300 counts per minute. Operating temperature range is −40 to 150 F. **Commercial Div., Librascope Inc.**, 40 E. Verdugo Ave., Burbank, Calif. L

Circle 735 on Page 19

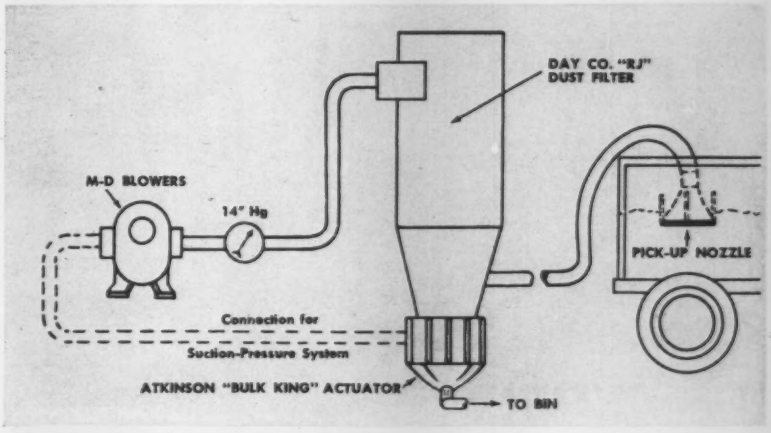
Drafting-Board Attachment

for parallel-ruling units

New counterbalance attachment for parallel-ruling units is designed to hold a straightedge firmly at any fixed position, at board angles from near horizontal to full vertical. Two assemblies are required to support weight of straightedge properly. Each assembly consists of a constant-tension device mounted at top edge of drawing board, plus a metal hook-bracket for mounting on straightedge. When board is depressed to horizontal or near horizontal angles, less tension is required and only one assembly is



NEW VACUUM METHOD
Using M-D 3-Lobe Blowers Unloads 1,200 Bu. of Wheat Per Hour



Two Model 5511 M-D Blowers operating in parallel furnish 1,600 scfm, 14" Hg continuous vacuum

Atkinson Milling Co., Minneapolis, unloads 1,200 bushels of wheat per hour (that's 72,000 pounds!) from standard trailers with a new vacuum method using M-D 3-Lobe High Pressure Rotary Positive Blowers. The diagram shows the simplicity of the new system employing an Atkinson "Bulk King" Actuator, a Day Co. "R.J." Dust Filter and two M-D Blowers operating in parallel. Economies are: Only one operator needed . . . low installation cost—far less than for system of lifting and dumping trailer . . . lower shipping costs . . . elimination of dust and infestation.

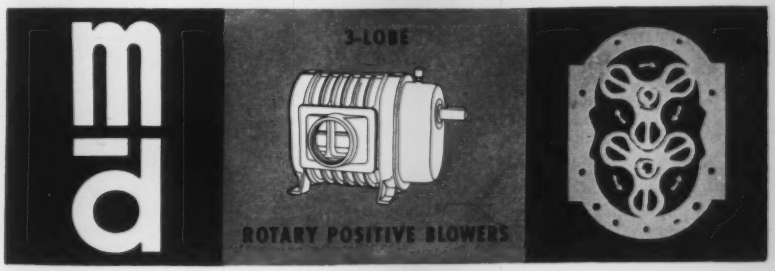
This system can easily be converted to a suction pressure system for handling flour, or granular material, by connecting the outlet side of the M-D Blowers to the rotary feeder valve, as indicated by the dotted line in the diagram above. A typical installation using two-stage M-D High-Pressure 3-Lobe Blowers, Models 5509 and 5507.5, can handle 1,700 pounds of flour per minute from trailer to storage bin. *Ask about other applications of low-cost, high pressure M-D Blowers!*

Specially designed suction nozzle enables one man to unload 40 foot trailer of wheat in 35 minutes

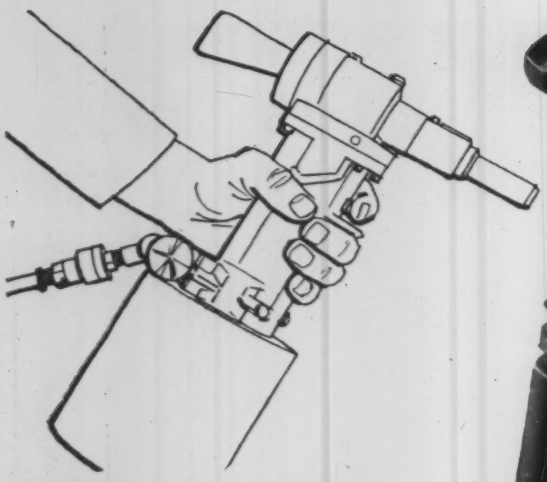
WRITE FOR NEW FOLDER GIVING PERFORMANCE DATA

M-D BLOWERS, INC. • 100 FOURTH STREET • RACINE, WIS. • MElrose 4-5521

A Subsidiary of Mieble-Goss-Dexter, Incorporated



Circle 565 on Page 19



Vibration-proof fastening for transportation equipment by Townsend

Townsend blind rivets* and Townsend Lockbolts† provide economical, vibration-proof fastening for all types of transportation equipment. Both in manufacture and repair, Townsend transportation fasteners are easy and fast to install—giving high worker productivity. Once installed, they make a tight joint which will resist the loosening effects of vibration indefinitely—lowering maintenance costs for your customers.

For information on how Townsend blind rivets and lockbolts can give you better fastening for less money, consult your Townsend representative or write for literature to Townsend Company, P. O. Box 237-E, New Brighton, Pa.

*Patents issued and pending
†Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

needed. Attachments for each side are available in pull-strengths of 11, 14, and 17 oz. **Frederick Post Co.**, P. O. Box 803, Chicago 90, Ill. J

Circle 736 on Page 19

Servo Kit

is used for breadboard and operational models

Servo construction kit utilizes AGMA Precision Class II gears, and ABEC Class 7 bearings. Breadboard incorporates equally spaced, jig-bored holes. System can be used for operational units as well as for breadboard work. Completed unit is

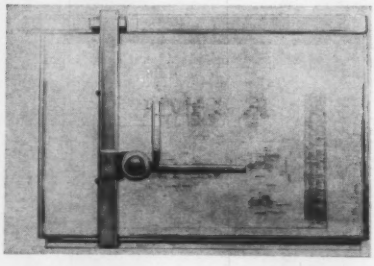
compact, rugged, light, and is suitable for base or panel mounting. **Gap Instrument Corp.**, 33 S. Grove St., Freeport, L. I., N. Y. D

Circle 737 on Page 19

Drafting Machine

x-y unit is balanced for all board angles

New Tracmaster x-y track drafting machine has numbered graduations provided on each track at precise 10-in. intervals. Graduations divide entire drawing area into a 10-in. grid pattern, useful for establishing widely separated reference points or for measuring and drawing long lines with no cumulative error. Unit is automatically balanced for operation at all board angles without adjustment. It mounts without need for alignment, and accuracy



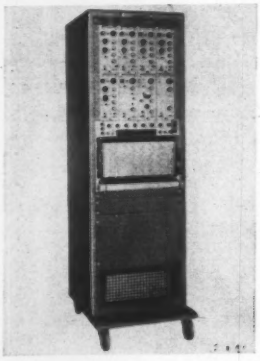
is permanent. Concealed counterweight provides proper balance automatically without adjustment. Unit is equipped with standard protractor head with full 360-deg visibility and graduations, automatic 15-deg index stops, and engine-divided horizontal and vertical scales. **Universal Drafting Machine Corp.**, 7960 Lorain Ave., Cleveland 2, Ohio. G

Circle 738 on Page 19

Recording System

has nine chart speeds from 0.25 to 100 mm per sec

Series 350 six and eight-channel direct-writing oscillographic recording system is packaged in a single mobile vertical cabinet. Unit includes flush-front recorder with paper take-up, fully transistorized plug-in power amplifiers, and power supply, in 17½-in. panel space. Power amplifiers are mounted behind recorder. Limiter circuit is located ahead of current-feedback power amplifiers to prevent saturation or cut-off. Complete recorder-power amplifier assembly has a sensitivity



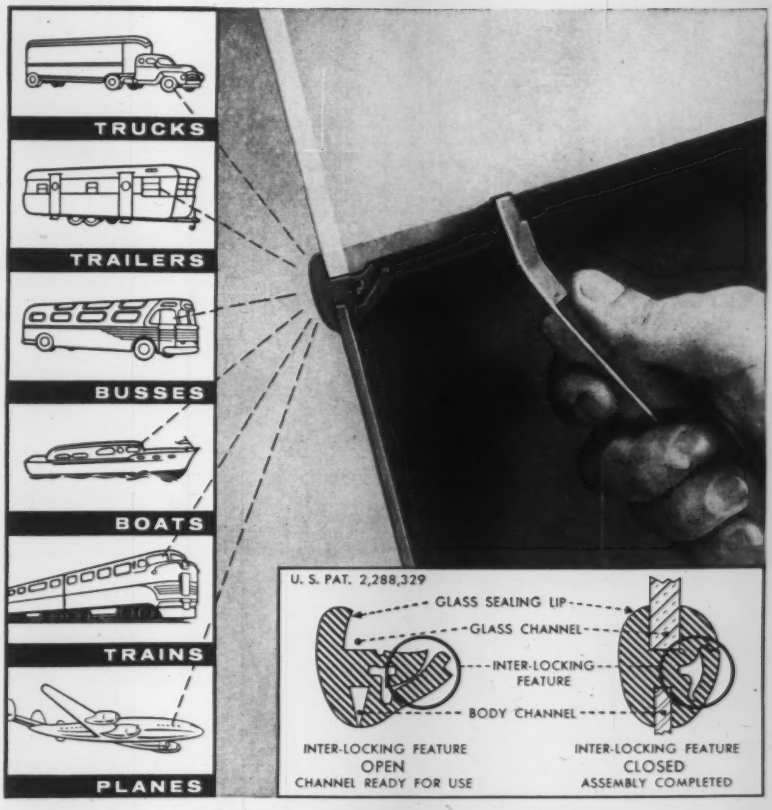
of 0.1 v per div. System has electrical pushbutton control of nine chart speeds from 0.25 to 100 mm per sec. **Industrial Div., Sanborn Co.**, 175 Wyman St., Waltham 54, Mass. B

Circle 739 on Page 19

Thermal Ribbons

for temperature sensing are self-adhering

Model S7B self-adhering thermal ribbons are pressed into position on any flat, curved, or irregular surface where temperature is to be sensed.



Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental —rubber specialists since 1903.

Engineering catalog.

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Circle 567 on Page 19

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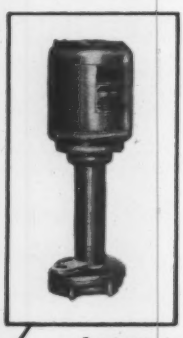
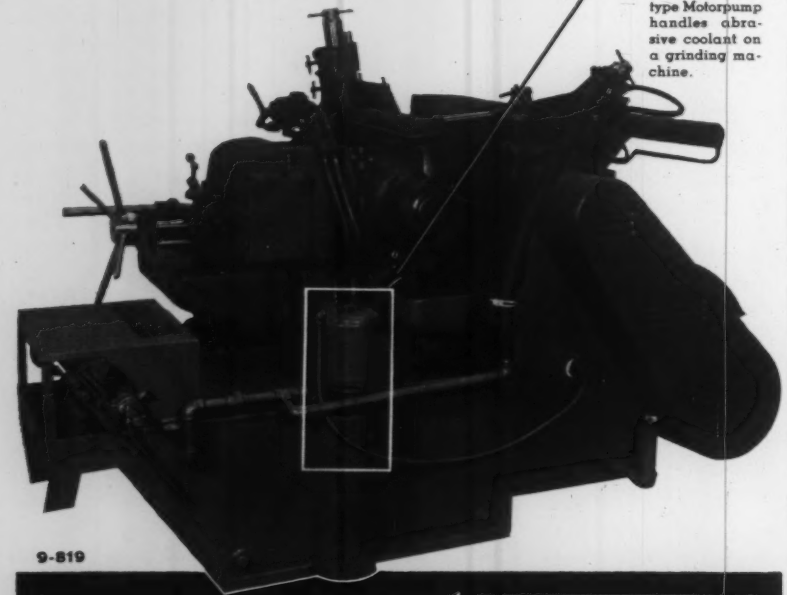
Motorpumps are designed in a wide variety of types and sizes to meet your exact requirements. Why not get complete information on Ingersoll-Rand Motorpumps from a thoroughly trained pump specialist. Call your nearest I-R branch office or write direct.



An immersion-type Motorpump handles abrasive coolant on a grinding machine.



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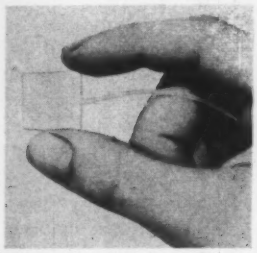


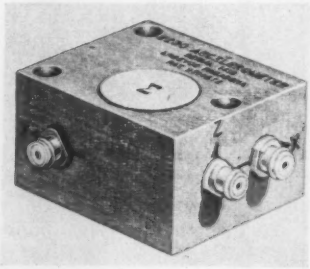
The thin, flexible resistance-wire sensors are used in airborne and industrial temperature monitoring and measuring applications, and can be built into equipment for use when equipment is operating. Ribbons are furnished with calibration curve for operating range of −60 to 160 C. Ribbons are also available without self-adhering feature, and are for use where taped or cemented installation is desired. **Minco Products Inc.**, 740 Washington Ave. N., Minneapolis 1, Minn. J

Circle 740 on Page 19

Accelerometers

for simultaneous measurement in three axes

Two new triaxial accelerometers meet vibration specifications for simultaneous measurement in three axes. Three sensing elements are mounted in mutually perpendicular planes within a small block measuring 0.75 x 1.25 x 1.31 in. Model 2243 operates over temperature range from −100 to 500 F with maximum change of 10 per cent in



sensitivity. Model 2230, shown, operates accurately over normal temperature range of 63 to 200 F. Both units have high natural frequencies of 25 kc or more to assure wide flat frequency response without spurious resonance. Sensitivities are 5 to 9 mv per g. **Endevco Corp.**, 161 E. California St., Pasadena, Calif. L

Circle 741 on Page 19

THE ENGINEER'S

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Recent Books

Introduction to a Study of Mechanical Vibration. *By G. W. Van Santen; 310 pages, 6 by 9 in., clothbound; published by the Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$8.50 per copy postpaid.*

This book contains the elementary theory of mechanical vibrations, as well as some of the problems encountered in practice. Topics discussed include free vibration, damping, isolators, torsional vibrations, and bending vibrations.

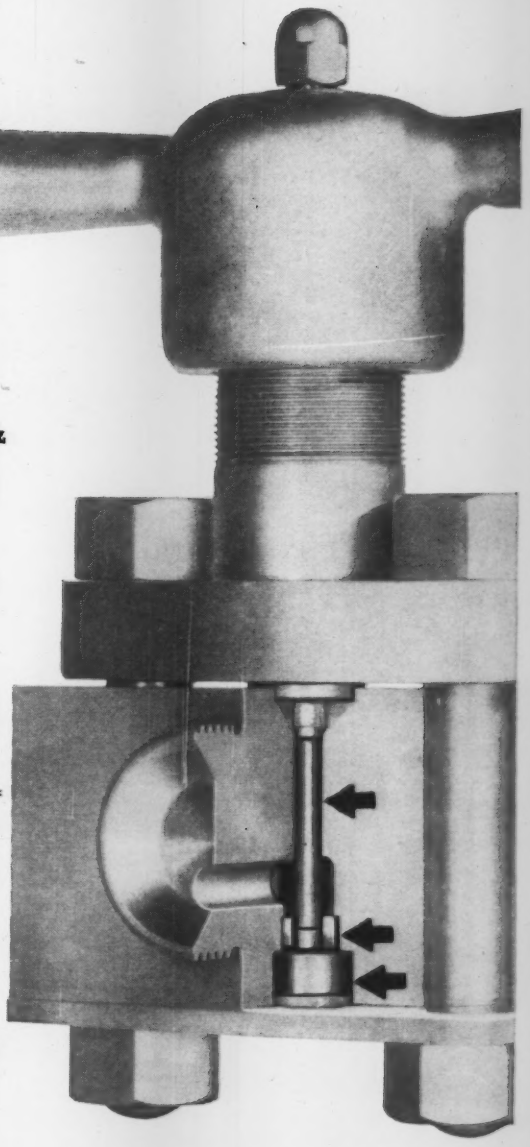
Introduction to Nuclear Engineering. *By Richard Stephenson; 491 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

This second edition gives a basic treatment of the problems encountered in the nuclear energy field. Among the topics discussed are nuclear fission, nuclear chain reactor, reaction theory, radiation shielding, reactor materials, reactor controls, and remote handling equipment.

Electric Machinery. *By Clifford C. Carr; 537 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$9.25 per copy postpaid.*

Types of construction used in ac and dc machines, transformers, and dynamos are covered in this book. Divided into two sections, the first part of the book includes topics such as types of windings, voltage relations, magnetic-field relations, energy losses, energy flow, efficiency, ratings, and basic torque relations. The remainder of the book deals with the application of these principles and relations to the analysis of machine performance.

Control System Components. *By John E. Gibson, associate professor of Electrical Engineering, Purdue University and*



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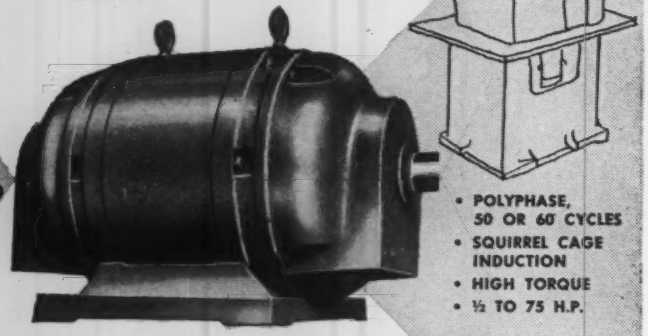

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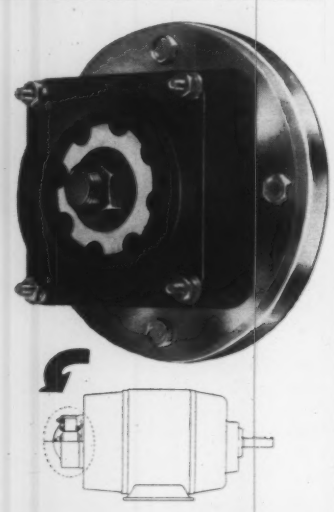

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Franz B. Tuteur, associate professor of Electrical Engineering, Yale University; 493 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., 330 West 42nd St., New York 36, N. Y.; available from MACHINE DESIGN, *$12.00 per copy postpaid.*

As an analytical treatment of the components commonly used in servomechanisms and other feedback control systems, this book contains discussions on electronic, electric, mechanical, hydraulic, and pneumatic components.

Discussed in this book is a theoretical approach to selection of control-system components. Included is information on work synthesis, system analysis of valve-operated hydraulic systems, and relay amplifiers.

Fluid Dynamics and Heat Transfer. *By James G. Knudsen, professor of Chemical Engineering, Oregon State College and Donald L. Katz, professor of Chemical Engineering and chairman, Department of Chemical and Metallurgical Engineering, University of Michigan; 576 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

This book presents the fundamentals of fluid dynamics which are basic to convection heat transfer theories. Material is developed from the application of first principles in fluid dynamics and heat transfer through the practical formulations used in design procedures.

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New Standards

American Standards. *Each publication is 8 by 10½ in., paperbound and side stapled. Copies are available from American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.*

The following standards are available:

American Standard Steel Butt Welding Fittings, ASA B16.9-1958; 14 pages, $1.50 per copy.

Slotted and Recessed Head Tap-

ping Screws and Metallic Drive Screws, ASA B18.6.4-1958; 143 pages, $4.00 per copy.

Association Publications

The Annealing of Low Carbon Steel. *138 pages, 8¾ by 11 in., clothbound; published by Lee Wilson Engineering Co. Inc., Cleveland, Ohio; and available from American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; $7.50 per copy.*

This book contains twelve papers presented at the International Symposium on The Annealing of Low Carbon Steel. These papers cover the latest annealing techniques and research findings, and discuss economics of the annealing operations.

Government Publications

Corrosion Preventive Additives, PB 131459. *115 pages, 8 by 10½ in., paperbound; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C., $3.00 per copy.*

This report contains the results of investigation on the lubrication properties of new corrosion preventives for use as lubricant additives.

NACA Technical Series. *Each publication is 8 by 10½ in., paperbound; copies available from National Advisory Committee for Aeronautics, 1512 H St., N.W., Washington 25, D. C.*

The following reports are available:

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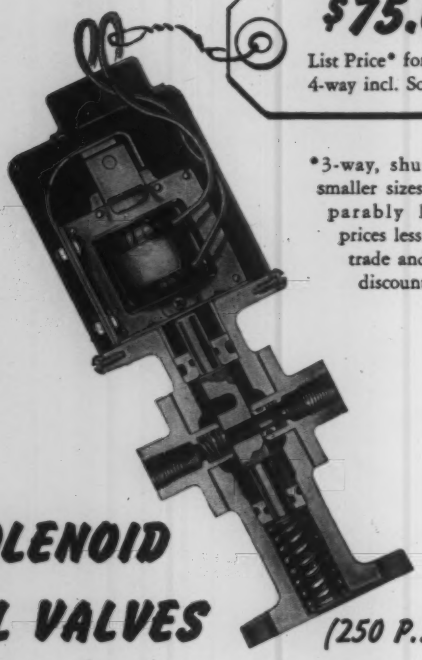

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WHERE	WHY	HOW
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Pressure testing in automotive production	Oil gets contaminated by scale in castings (not critical to dirt) reduced maintenance	Sealing surfaces in constant, intimate contact, dirt can't lock valving members – saves coil burn-out
Hydraulic work feed apparatus	(Leakproof) ... as versus spool valves which cause over-demand on hydraulic system	Positive shut off of internal port to port leakage and of course, no external leakage
Machine tool chucking & clamping	Maintaining safe holding pressure (leakproof)	Saving auxiliary equipment such as pilot operated check valves
Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
Solenoid controlled hydraulic system on machine you build	Better performance Lower manufacturing costs Reduce service problems	Shear-Seal valves have full flow, are leakproof, not sensitive to dirt Low priced, less auxiliary equipment and labor cost. Valves don't stick, saving coil burn-out; stay leakproof indefinitely, seals are wear compensating

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CONTROL VALVE DIVISION **barksdale valves**

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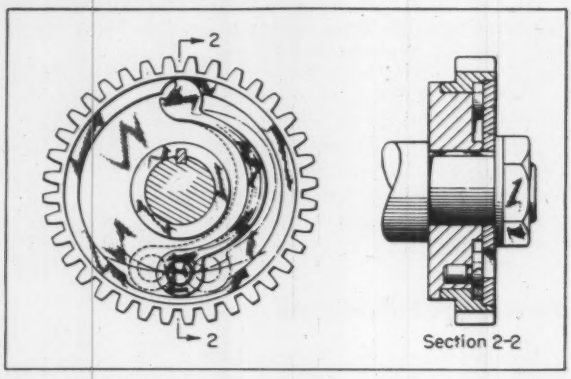
NOTEWORTHY

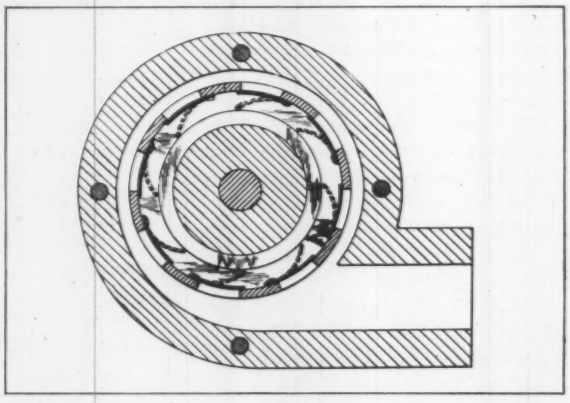
Patents

Vibration-Damping Gear



Flexing of a C-shaped spring fitted between the hub and the tooth ring of a gear assembly damps relative rotation of the two parts caused by momentary irregularities in transmitted torque. One end of the spring fits over a pin fixed in the hub. The other end fits into a semicircular seat in the tooth ring. The spring functions in either direction of rotation. Particularly useful where space is limited, the resilient assembly is about the same size as a conventional gear of the same capacity. *Patent* 2,841,000 *assigned to Caterpillar Tractor Co., Peoria, Ill., by John H. Parks and Rollin P. van Zandt.*

Temperature-Sensitive Pump



Bimetallic construction enables impeller vanes in a rotary pump to change shape with changes in the temperature of the fluid pumped. Changes in the vanes cause corresponding changes in pump capacity. Zero output results when the vanes are fully retracted in their cage-like rotor. This condition can be arranged to occur at either minimum or maximum temperatures

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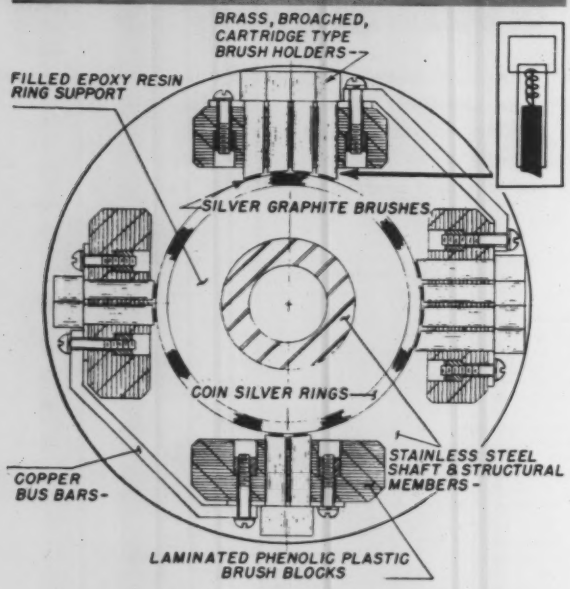
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The drawing above suggests how thoroughly the Superior staff works out every detail of a job. Superior will design and build any or all parts of a brush assembly, *OR* we will build to your design.

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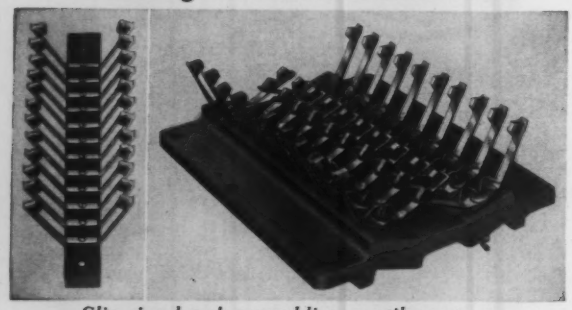


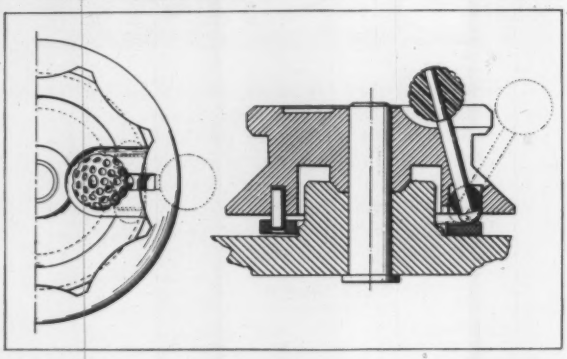
Slip ring brush assemblies, cantilever type.

Superior CARBON PRODUCTS, INC.
9115 GEORGE AVENUE • CLEVELAND 5, OHIO

BRUSHES • CONTACTS • SLIP RING ASSEMBLIES
POWDER METAL PARTS • MECHANICAL CARBONS

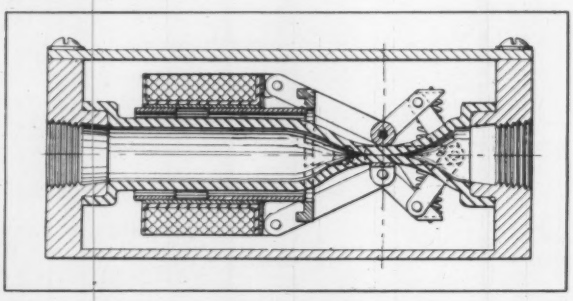
encountered. *Patent 2,845,869 assigned to Thompson Products, Inc., Cleveland, by Edward J. Herbenar.*

Locking Control Knob



Manual operation of a toggle lever built into a knob enables the knob to be locked in any position around its shaft, or freed from any position for rotation without restriction. A washer, carried with the knob as it turns, assures a broad friction surface for the locking action. The lever, itself, is held in its "lock" position by toggle action. *Patent 2,845,145 assigned to the United States of America by Charles M. Lee.*

Pinch-Off Valve



Unobstructed flow is assured in a quick-operating valve when a solenoid, concentric with the flow path, activates a linkage to release pressure on a pliable tube. In the valve's relaxed state, flow is pinched off by parallel pressure bars forced together by a spring acting through a linkage. The valve is opened when the solenoid is energized, drawing into its core a cylindrical armature connected to the linkage. Patent 2,842,331 *assigned to Minneapolis-Honeywell Regulator Co., Minneapolis, by Donald G. Anderson.*

Universal Expansion Joint

In an expansion joint, spherical ends of two pipes in a cylindrical housing permit axial movement of the joint components, as occurs with temperature changes, and also lateral movement, as occurs under misalignment. The ball ends seat in socket-shaped, spring-loaded seals. The springs are conical to accommodate

A Marion type 5760 stripping shovel in action. The dipper could fill two railroad cars in a single pass.

Farrel® gears take loads in stride on world's largest power shovels

Precision generation, combined with the use of highest-grade materials, give Farrel gears the ability to withstand the heaviest shock loads encountered in machine applications. The *backbone* in the gears—formed by the meeting of the two helices without a center groove—puts the entire face width of the gear to work. This pays off in extra strength and greater load-carrying capacity.

These are a few of the reasons why Farrel gears are "naturals" for the main-hoist drive in the largest power shovels ever built. Made by Marion Power Shovel Company, these giant machines have dipper capacities as high as 75 cubic yards.

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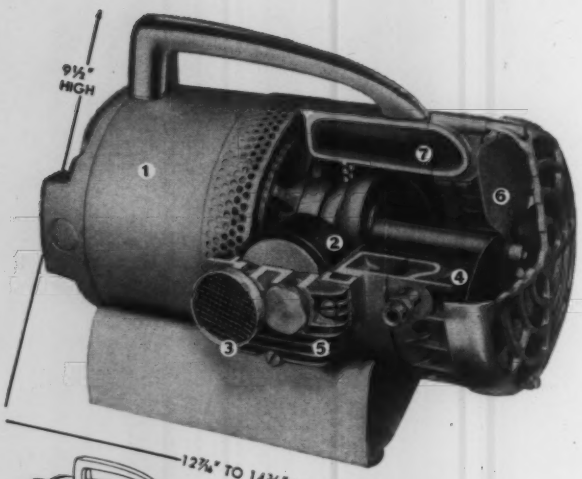
FB-1150

Circle 575 on Page 19



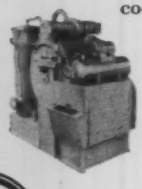
Oil-Free COMPRESSED AIR

CLEAN, COOL, DRY... FROM THIS PORTABLE OR BUILT-IN UNIT

Here is a compressor which doesn't need lubrication of any kind—eliminates an oil separator—*ends expensive lubrication maintenance.* Where else can you find all these features—

Easily carried portable model.

"Duplex Unit," mounted on horizontal tank.



B&G Compressor built into dry cleaning machine.

1. **Special motors.** Built by B&G—ball bearings *permanently* grease packed.
2. **Graphite piston rings and skirts.** Never need lubrication—operate for years without destroying mirror-finish of cylinder walls.
3. **Dry valve construction.** Inlet and exhaust valves are positive sealing without presence of oil.
4. **Safety valve.** (Not visible.) Provides constant bleed-off at maximum pressure.
5. **Bi-metal cylinder head.** Transfers heat faster—shrink-fitted around cast iron cylinder.
6. **Blast cooled.** Low temperature operation assures higher efficiency, longer life.
7. **Combined aftercooler, pulsation chamber, moisture separator.** Assures cooler, drier air at uniform pressure.

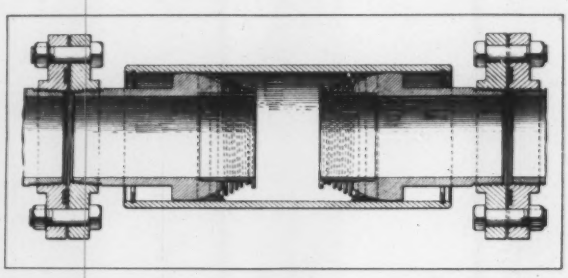
B&G Oil-less Compressors are available in a complete line of portable tank-mounted and tankless models. Send for catalog GO-1156.

B & G

Oil-less AIR COMPRESSORS

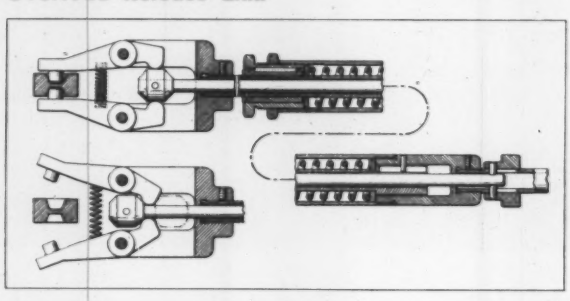
BELL & GOSSETT COMPANY

Dept. FK-67, Morton Grove, Illinois



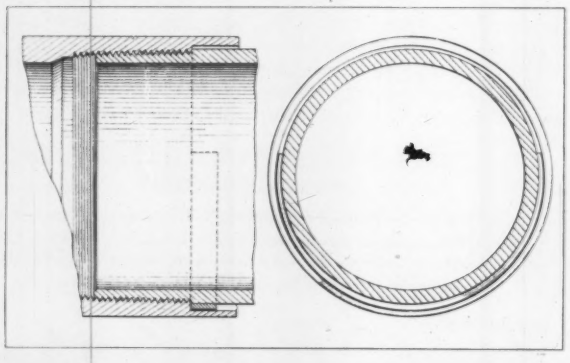
lateral and angular movements of the joint members. Retaining rings in the ends of the housing prevent the ball ends from leaving the housing entirely. *Patent 2,845,283 assigned to Rotherm Engineering Co., Chicago, by Henry S. Kuhn.*

Overload Release Link

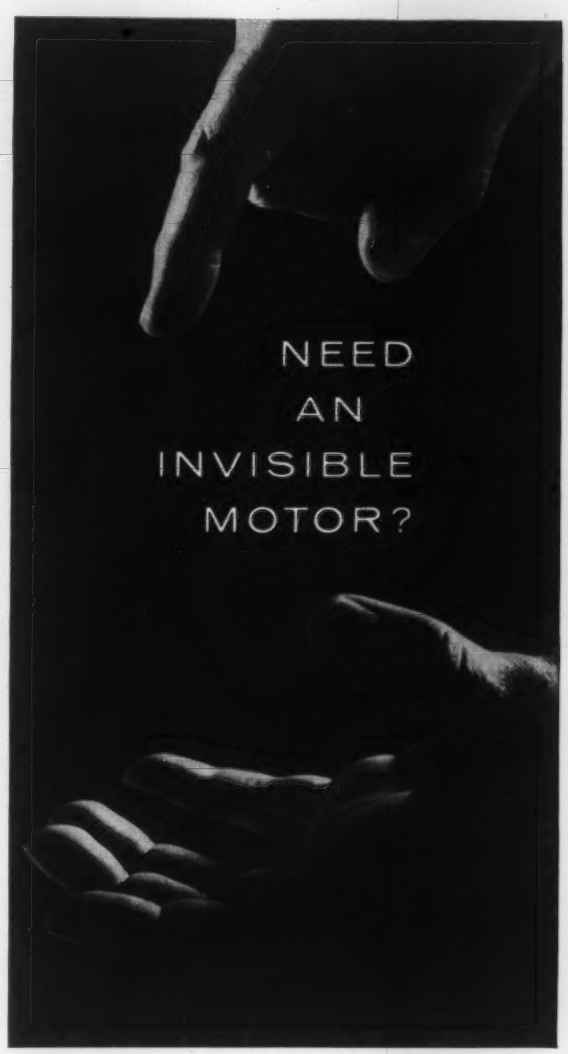


Pivoting fingers in the head of a link assembly automatically release an adjacent part as the head moves axially, with respect to the link body, under tension or compression loads. Action of the fingers is controlled by a cylindrical cam at the end of a rod fixed in the body. A threaded gland, adjustable axially, loads a body spring which determines the limits of tension and compression at which the fingers open. *Patent 2,844,048 assigned to The American Pulley Co., Philadelphia, by Richard A. Bennett.*

Tube Joint Lock



Having been joined by conventional threads, two ends of pipe or tube are locked by an arc-shaped, tapered wedge which prevents further relative turning of the members in either direction. From the



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And we customize beyond invisibility, too. Give you special torque or high-temperature ratings, high or low L/D ratio . . . even make the motor corrosion resistant for submersibility in water, gasoline and other liquids.

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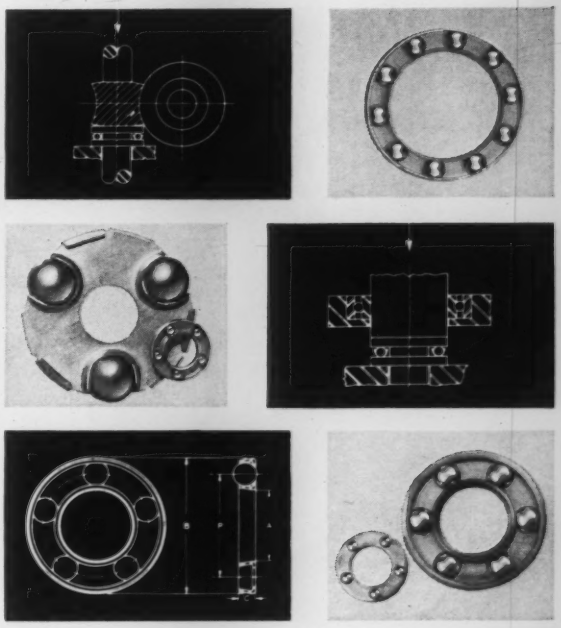

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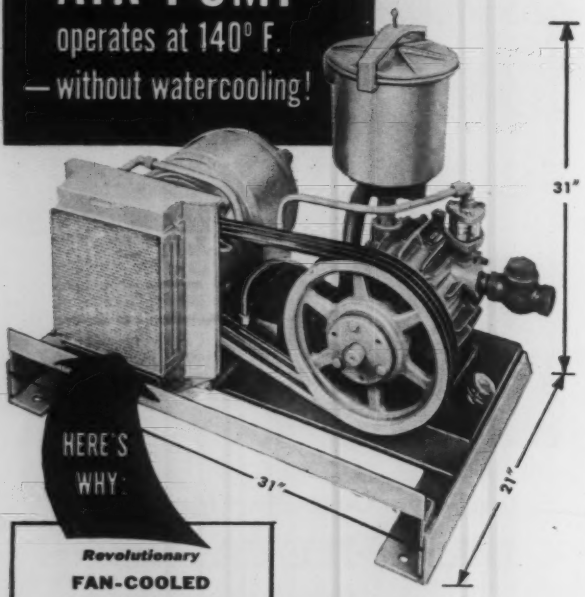
LEIMAN ROTARY POSITIVE HIGH VACUUM AIR PUMP

operates at 140° F. — without watercooling!

VACUUM: to 29.9" Hg.

CAPACITY: to 40.8 c. f. m.



Revolutionary

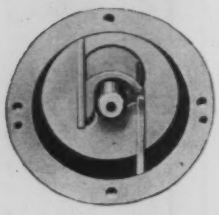
FAN-COOLED OIL RADIATOR

(Patent Approved)

continuously circulates pre-cooled oil through pump, reduces heat on pump parts, prevents overheating and jamming. Oil provides seal for vacuum. Permits speeds up to 800 r.p.m., provides greater capacity with smaller pump.

- No water pipes—no leaks—place pump anywhere
- No oil vapor
- Rugged—for 24-hour continuous operation, without overheating
- Every pump performance-tested before shipment

You don't need bulky, high-priced air pumps and complicated water pipe hookups to produce continuous high vacuum. Leiman engineers have the answer in a compact package . . . the oil-cooled Leiman High Vacuum Pump. Run it 24 hours a day—it maintains an average temperature of 140° F. Run it year after year—it maintains fully rated capacity, without troubles or shutdowns, because it features the



"Lifetime" Leiman 2-Wing Vacuum Pump with Patented Wing Adjuster

Precision-honed cylinder walls are made of durable cast iron; wings are made of wear-resistant steel (not composition). Automatic wing adjuster assures constant wing-to-wall contact, prevents sticking or binding. Pump takes up its own wear to provide maximum vacuum for years.

WRITE for latest 16-page catalog describing complete line of Leiman Vacuum Pumps, plus Application Book of "how-to-do-it" blueprints.

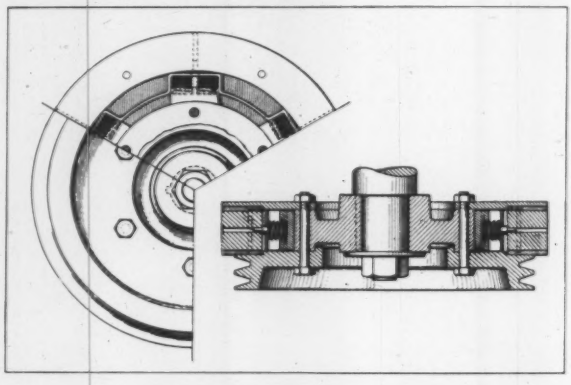
LEIMAN BROS, Inc.

158 Christie St. Newark 5, N. J.

Established 1887

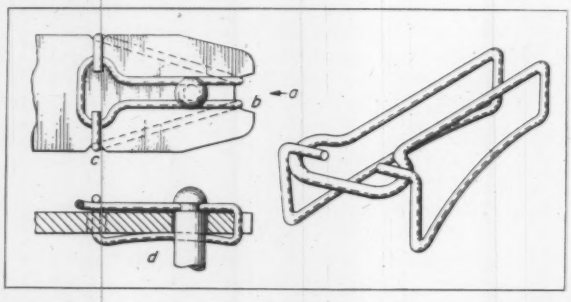
thickest section at its center, the wedge is tapered toward both its ends. Its inside radius, smaller than the pipe or tube OD, causes the wedge to grip the male member of the joint. The wedge is seated in an eccentric counterbore after assembly. Any motion jams the wedge into a narrower section of the counterbore. *Patent* 2,845,106 *assigned to Baker Oil Tools Inc., Los Angeles, by Reuben C. Baker.*

Torsional-Vibration Damper

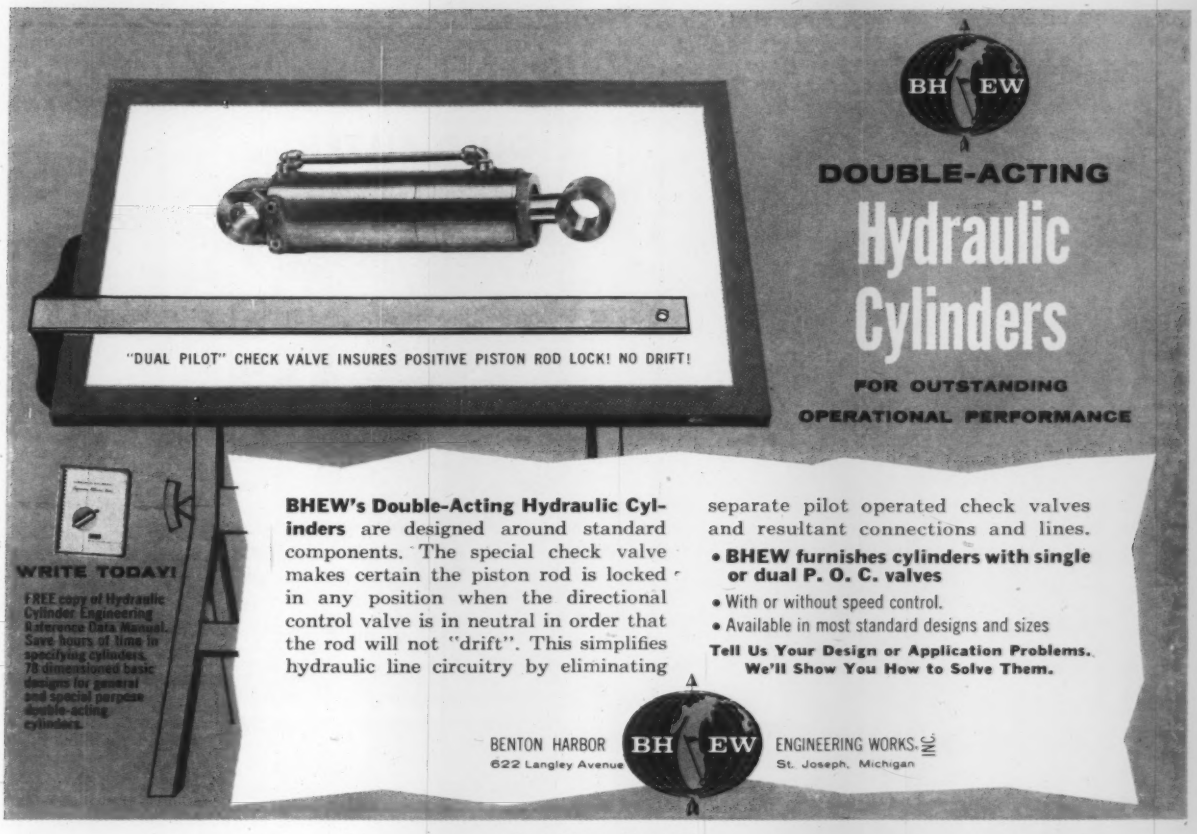


In a torsional damper assembly, spring-loaded shoes bear upon the circumference of a friction wheel with varying pressure to provide automatic adjustment of damping capacity with angular speed. Continuous damping is furnished by a flywheel rim that slips between side plates when momentary torque variations occur. The shoes exert less damping with increased speed as they are forced radially outward by centrifugal action. *Patent* 2,844,972 *assigned to Lipe-Rollway Corp., Syracuse, N. Y., by Charles B. Spase.*

Spring-Wire Fastener



Resilience in three directions enables a formed, spring-wire clip to join two parts quickly, positively, and in a manner to prevent relative motion within the assembly. The clip is forced onto the assembly with a single motion, *a*. Original shape and inherent resilience cause the wire to bear outward against inclined planes, *b*, inward in notches, *c*, and upward against a surface, *d*. *Patent* 2,845,291 *assigned to General Motors Corp., Detroit, by Bewley D. Priestman.*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BHEW's Double-Acting Hydraulic Cylinders are designed around standard components. The special check valve makes certain the piston rod is locked in any position when the directional control valve is in neutral in order that the rod will not "drift". This simplifies hydraulic line circuitry by eliminating separate pilot operated check valves and resultant connections and lines.
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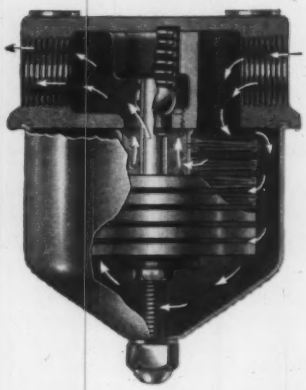
CLEANABLE MICRONIC LIQUID FILTER



• For the first time, the cleanability and long life of an all metal filter has been combined with extremely small particle removal. The Air-Maze liquid filter is available in many degrees of filtration, down to 98% removal of 10 microns and larger. Constructed of specially processed wire mesh, filtering media is arranged in form of multiple discs which afford over six times more effective area than the same size cylinders. Built-in relief valve optional. Sizes from 1.7 to 720 gpm. Write for bulletin LFC-556. **AIR-MAZE CORPORATION**, Cleveland 28, Ohio.

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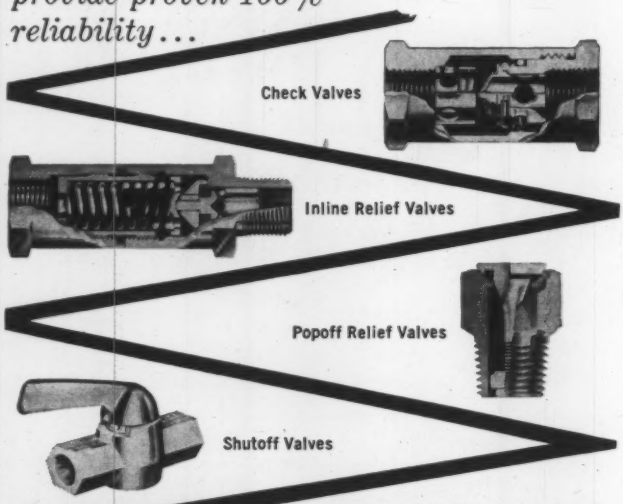

These and other standard and special valves are available for virtually all of your exacting service requirements.

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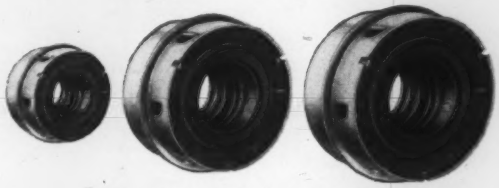
NEW HY DUTY J-2 SEALS

FOR THOSE APPLICATIONS THAT REQUIRE THE BEST



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of exceptional durability—
for 5/8", 1" and 1 1/8" diameter shafts.

The economy is found in its long life and dependability.

An unbeatable combination when used with the Schwitzer Ceramic Nose Pump Impeller.

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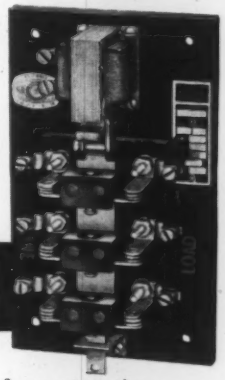

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- Simplified wiring.
- All parts easily accessible for service without disturbing other parts.
- Fine silver contacts . . . plus heavy compression springs . . . assure maximum conductivity.

Available in 1 to 5 pole, 25 and 50 amp. sizes. Other contactors, magnetically or mechanically held, up to 400 amps.

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2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
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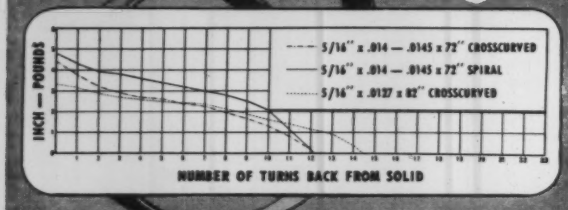
This CURVE Makes This SANDSTEEL SPRING Performance CURVE Possible


INCH — POUNDS
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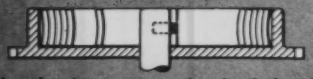
NUMBER OF TURNS BACK FROM SOLID

Crosscurving is an exclusive Sandsteel spring-making process which gives a longer, more even release of energy. This super performance makes possible the use of longer, thinner springs to produce the consistent power required in many applications.

Only a superior metal can withstand the Sandsteel crosscurving process. It is given a convex structure along the length of the strip and a concave curve across its width. The spring is wound against the convex curvature in which it was tempered.



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1. It tends to spring back into the shape in which it was tempered
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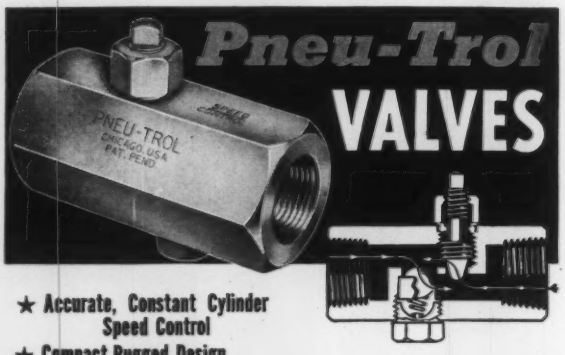
89-121

Pneu-Trol VALVES



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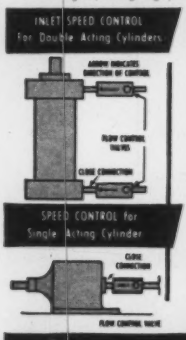

Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

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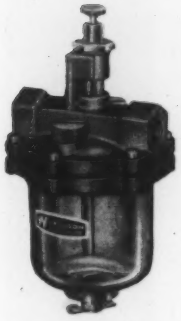
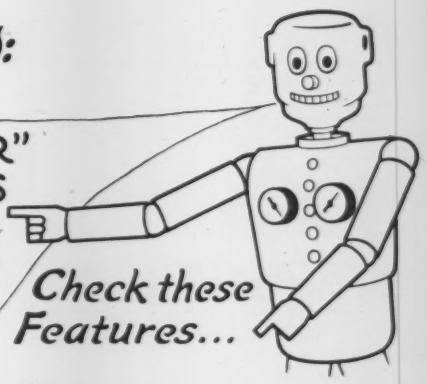


Otto Mation Says:



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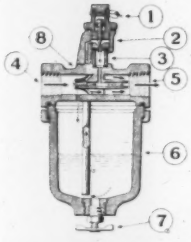

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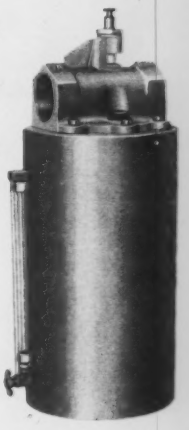

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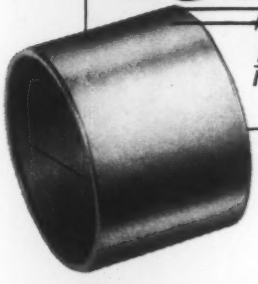
the RULON® T-LINER BEARING



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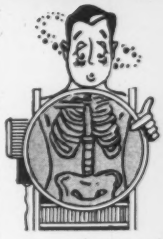
BOWSER

FLOW indicating DEVICES



Tell when liquids are moving, if quality is right, and indicate flow.

Fig. 55A Flow Sight

Fig. 811 Flow Indicator

Fig. 816 Teleflow Indicator

Plant and product engineers have relied on Bowser, liquid handling specialists since 1885, for prompt service. For sight glasses in single or double-window types, gravity or pressure models; or for electrical or mechanical indicators . . . there is a Bowser man nearby, ready to help you . . . quick!

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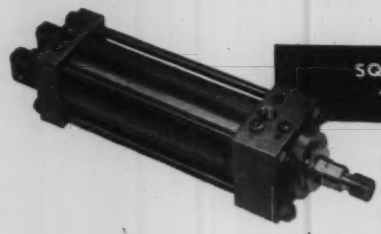

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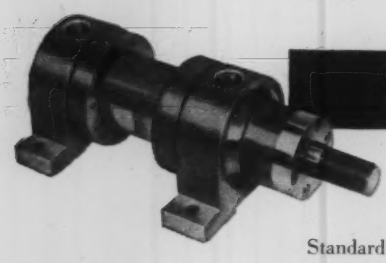

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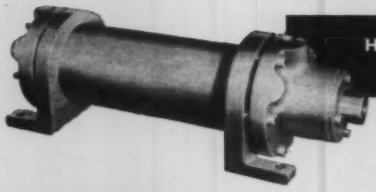

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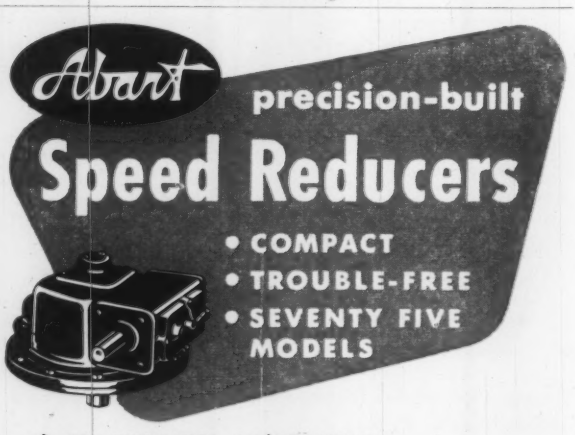

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Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

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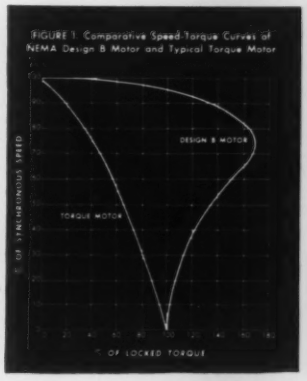
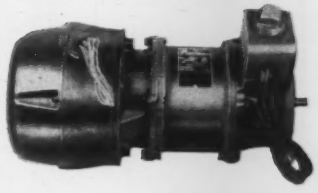
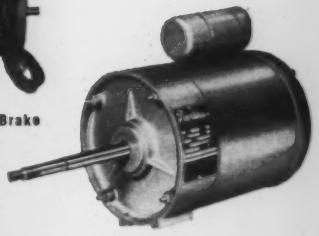


FIGURE 1. Comparative Speed-Torque Curves of NEMA Design B Motor and Typical Torque Motor
% OF SYNCHRONOUS SPEED
DESIGN B MOTOR
TORQUE MOTOR
% OF LOCKED TORQUE

The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.



Explosion-Proof Torque Motor With Brake



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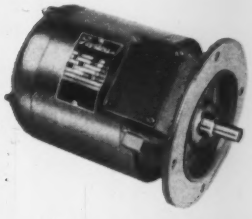

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NEW TORQUE BULLETIN

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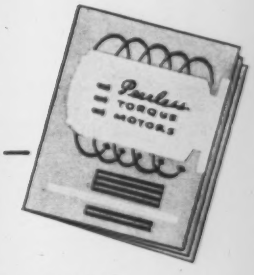

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THE Peerless-Electric® COMPANY
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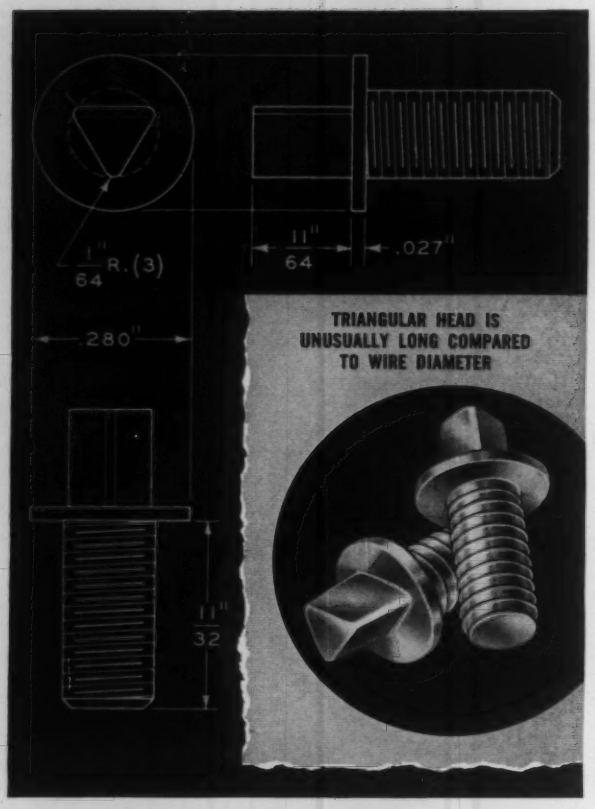

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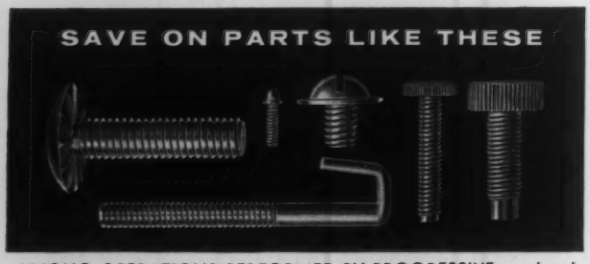

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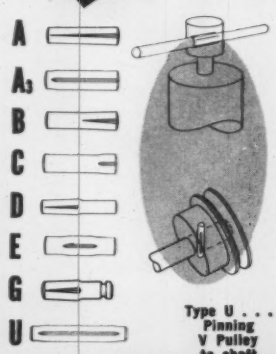

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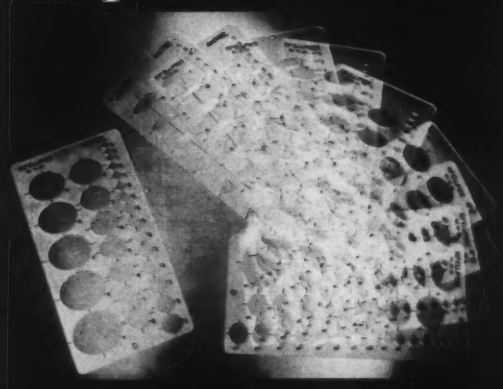

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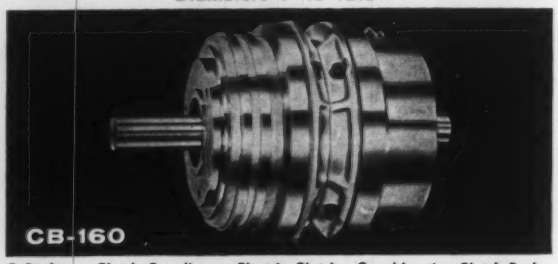

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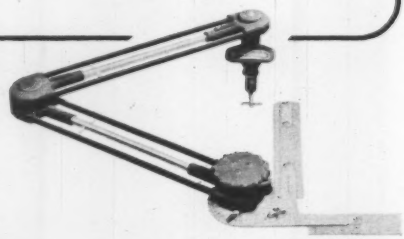

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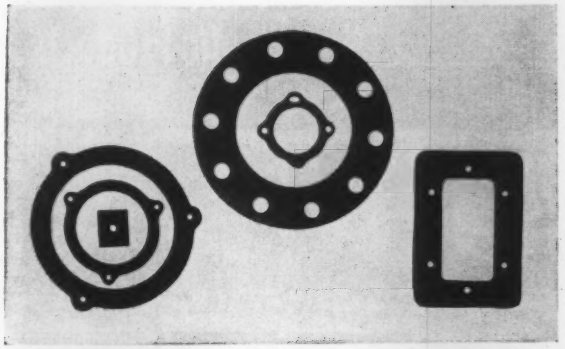

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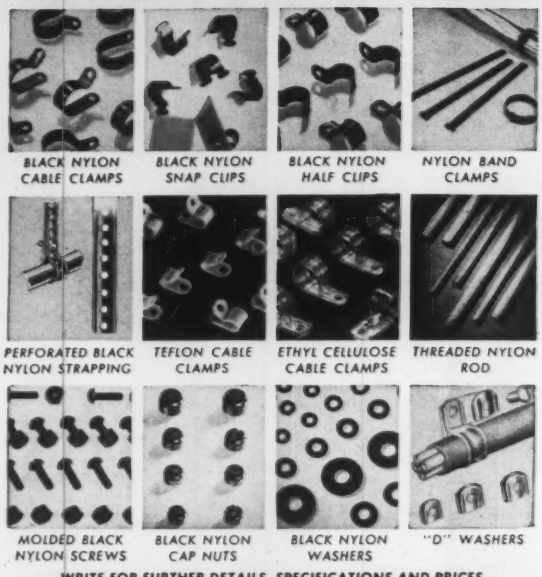

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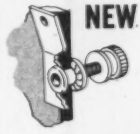
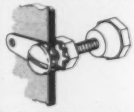
	
Found: Contact fastener and binding post. Expensive brass stud machined from hex stock, 8/32 thread, and brass nut. Hex must be recessed in plastic to stop rotation.	**Suggested:** Low-cost 10/32 threaded collar rivet and nut of steel. Automatically clinched to hold firm without hex or recess. Underwriters' ok'd change to steel if 10/32 thread.
	
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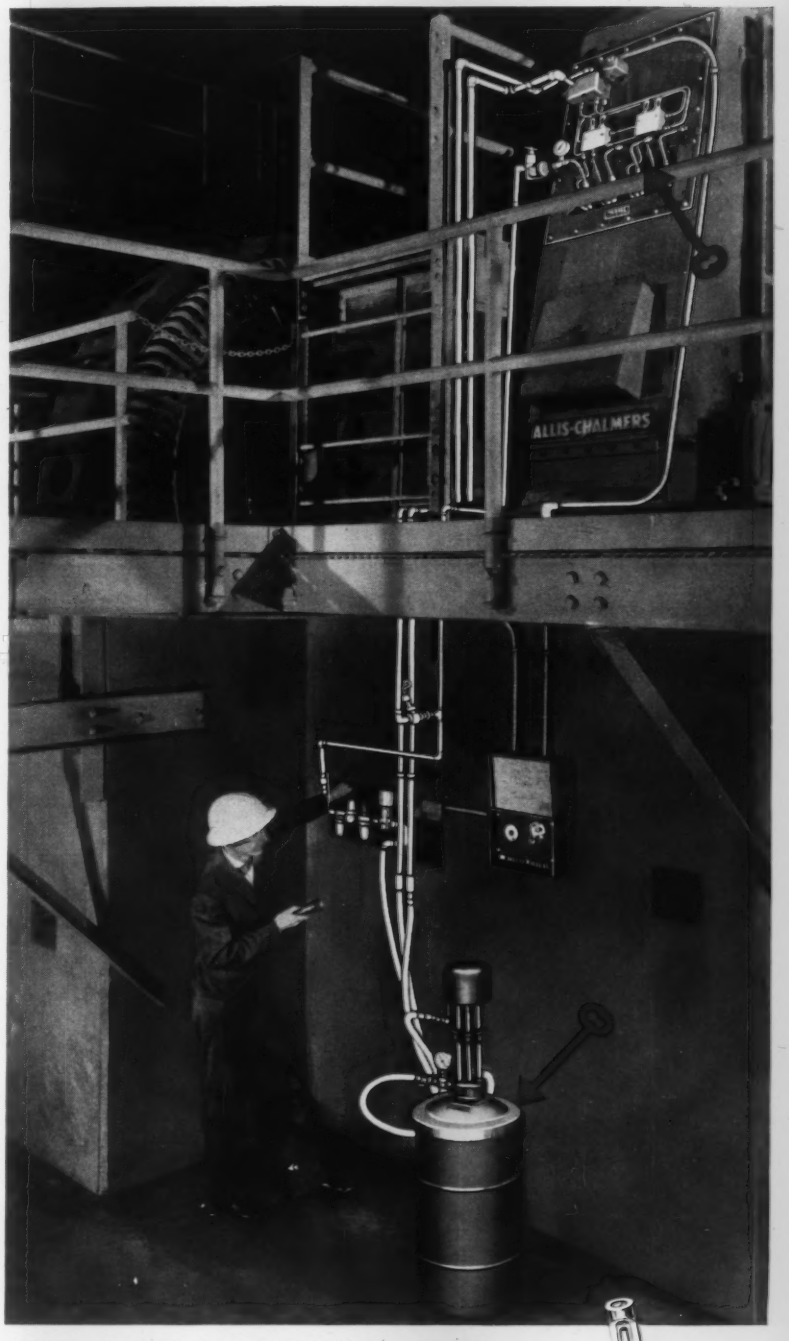

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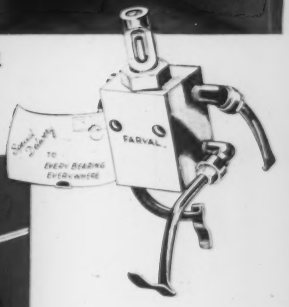

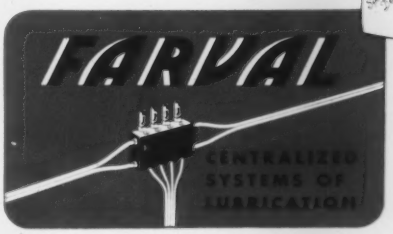

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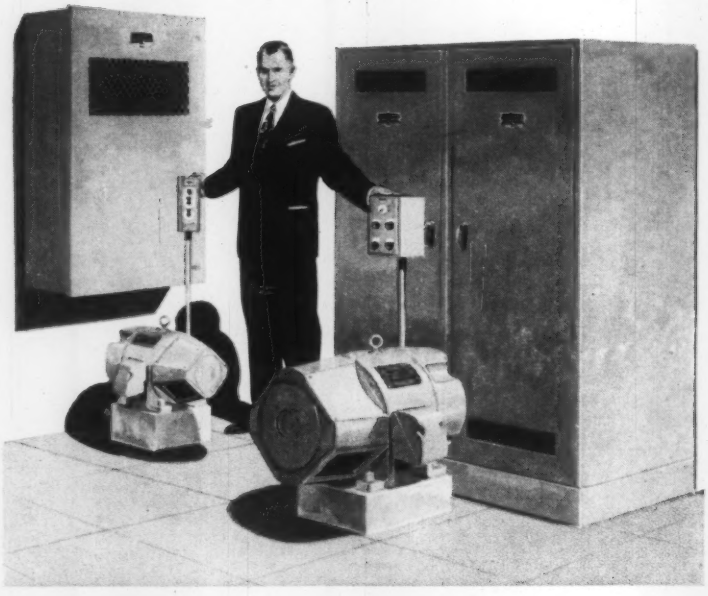

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